On Developing an Integrated Teaching and Learning Environment Providing a Bridge between Research Findings and Teaching Practice in Statistics Education

by

Gil Seong Mun

B.S. Statistics, Chonbuk National University, 2001

M.S. Statistical Informatics, Chonbuk National University, 2003

Submitted to the Faculty of

the Chonbuk National University in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

February 2011

CHONBUK NATIONAL UNIVERSITY

COMPUTER & STATISTICAL INFORMATICS DEPARTMENT

This dissertation was presented

by

Gil Seong Mun

It was defended on

December 15th 2010

and approved by

Byoung Chul Choi, Ph.D., Professor, Department of Statistics

Myung Hoe Huh, Ph.D., Professor, Department of Statistics

Joo Han Kim, Ph.D., Professor, Department of Statistics

Kyung Soo Han, Ph.D., Professor, Department of Statistics

Sung Suk Chung, Ph.D., Professor, Department of Statistics

On Developing an Integrated Teaching and Learning Environment Providing a Bridge between Research Findings and Teaching Practice in Statistics Education

Gil Seong Mun, PhD

Chonbuk National University, 2010

There is a gap between research findings in statistics education and teaching practice. Many researchers suggest various teaching methods and learning contents for improving students' understanding and developing problem-solving abilities in real problems, and they argue that such methods could improve student learning of statistics. Even though the research findings were verified, however, there are numerous barriers in the classes of the teachers, since they are not educational researchers. The questions that arise are: (1) How can teachers know the research findings; and (2) How can teachers implement the research findings in the classroom.

Actually, it is nearly impossible for teachers to read all the papers related to statistical education and they implement the research findings in their classes. Most teachers cannot apply the research findings because they do not know the research. Also, even if they get to know the research findings, they are reluctant to use the research findings for their teaching for several reasons such as time restrictions in preparing lessons, spatial restrictions, the difficulties in using technology and so on. As a result, most teachers adhere to teacher-centered instruction, which has been pointed out by many studies while students still recognize that statistics is

very difficult to learn. At the same time, students are reluctant to be attentive to the class work even though they think that the study of statistics needs considerable time and effort.

The purpose of this study is to create an environment which enables students to learn with enthusiasm and involvement, not as passive consumers but rather active participants. This study also presents an integrated environment in which the teacher is able to give immediate feedback to students by quickly understanding the students' learning status, and to use several pedagogies and various learning contents with minimum effort.

This study develops an integrated teaching and learning environment providing a bridge between research findings and teaching practice in statistics education by using the recent advanced technology. To develop the environment, the following design principles were considered:

- to enable various pedagogies, learning theories and contents to coexist;
- to accept changes in society and technology;
- to be able to collect and analyze Learning History Data;
- to support students participation, open and share learning outcomes;
- to support tools for students management and course management;
- to support tools for investigation to the state of use and class satisfaction; and
- to provide various roles and an individualized interface or view depending on the roles.

The developed environment proposed in this study compares Learning Management System, the infra of the teaching and learning environment, from a functional perspective. It also compares some e-Learning tools for statistics education.

Learning History Data and survey data were collected through using the developed environment in several classrooms. This study examines the usefulness of the environment based on the analysis results. The results indicate students' attitudes to things such as learning time, participation, concentration and solving their assignments on their own have changed positively.

The developed teaching and learning environment in this study is significant in the sense that it enables teachers to use several teaching and learning methods easily without increasing their workload. In particular, it contributes to students engaging in the classroom with ongoing concerns.

Table of Contents

List of Tables

List of Figures

1. Introduction

There are two major types of gaps that occur in the statistics classroom. The first is the gap between what teachers want to teach and what students want to learn. Teachers stick to a traditional teacher-centered instruction, which has been pointed out by a number of researchers, while students still recognize that statistics is very difficult to learn. At the same time, students are reluctant to be attentive to the class work even though they think that the study of statistics needs considerable time and effort. This dilemma could further increase hidden conflicts between teachers and students.

The second gap is that between teaching practice and research findings in statistical education. Many researchers suggest various teaching methods and learning contents for improving student understanding and developing problem-solving abilities in real problems, and they argue that such methods could improve student learning of statistics. Even though the research findings were verified, however, there are numerous barriers in the classes of the teachers, since they are not educational researchers. The questions that arise are: (1) How can teachers know the research findings; and (2) How can teachers implement the research findings in the classroom.

Actually, it is nearly impossible for teachers to read all the papers related to statistical education and then implement the research findings in their classes. Most teachers cannot apply the research findings because they do not know the research. Also, even if they get to know the research findings, they are reluctant to use the research findings for their teaching

for several reasons such as time restrictions in preparing lessons, spatial restrictions, the difficulties in using technology and so on. As a result, most teachers adhere to teacher-centered instruction, which has been pointed out by many studies.

Several studies related to statistics education are currently underway. However, there has been almost no study to bridge the gaps between research findings and teaching practice. It is a regrettable that many fine research efforts to improve statistics education are left side. While many researchers have recognized the importance of using technology in statistics education, most use of technology only aims to aid students' understanding and to deploy the learning contents. Consequently, the technology have been not used effectively but rather restrictively. The potential should be fully utilized to help students of modern technology centered society. Research needs to study an integrated teaching and learning environment providing a bridge between research and teaching practice, and that is the purpose of this study.

1.1. Purpose of Study

The purpose of this study is to create an environment which enables students to learn with enthusiasm and involvement, not as passive consumers but rather active participants. This study also presents an integrated environment in which the teacher is able to give immediate feedback to students by quickly understanding the students' learning status, and to use several pedagogies and various learning contents with minimum effort. In order to develop the integrated teaching and learning

environment suggested in this study, the following research questions will be studied:

1. Which tools should be provided for both teachers and students in an integrated teaching and learning environment, and what features and functions should such tools have?

2. How should the large data generated in the statistics course be collected, managed and analyzed?

3. How should the students' understanding and the students' learning behaviors be monitored?

4. How could the effective teaching and learning methods suggested by many researchers be applied and tested?

5. How to use the latest information and communication technology for pedagogical purpose?

1.2. Contribution to the Field

This study makes four major contributions to the field of statistics education. First, this study provides an environment in which several pedagogies and diverse contents can coexist. This study provides solutions which reduce teaching workload, enhances teaching quality, and offers various learning materials for students. Also, it helps teachers to build teaching models through application and verification of teaching and learning methods, suggested by number of studies, in teaching practices.

Second, this study provides remedies which enable teachers to objectively and thoroughly comprehend students' learning behaviors through

the analysis of automatically collected learning data of various types. This study provides the information needed for providing immediate feedback so that teachers can monitor students' understanding and learning behaviors more frequently; this differs from existing assessment methods in terms of processes such as midterm examination and final examination. Also, it provides information on the evidence of learning history data for understanding the problems in the use of teaching and learning content.

Third, this study provides pedagogical directions for accommodating social and technological changes with regard to rapid technological growth — particularly the latest information and communication advances. More and more, students are experiencing and enjoying new technologies such as Wireless Internet, Touch Screens and Smart Phones. Therefore, it is difficult to expect to attract concentration from students in the classroom unless new technologies can be fully adopted as pedagogical tools to enhance students' learning.

Finally, the integrated teaching and learning environment suggested by this study includes a design philosophy that can be applied to other disciplines as well as statistics.

1.3. Limitations of Study

There are several limitations that should be considered pertaining to this study. First, this study asserts that suitable learning materials for new environment are urgently needed. To do this, the proposed scheme needs the support of content experts who have a wide computing knowledge and are able to create contents for statistics education

developing statistical reasoning and thinking which, as emphasized in many studies, is closely connected with good quality contents. However, this study does not carry out investigations into designing and developing content. This study presumes the content would be provided by content experts.

Second, no comparative experiment was carried out in this study to claim the learning effectiveness. It was deemed impossible for students to be placed in random groups for the purpose of comparative experiment, and, even if it were possible, the researcher considers it ethically inappropriate.

Finally, in order for the proposed environment to be adopted effectively and efficiently in the classroom, both the teacher and students need to have a basic knowledge in using computers. Also, the classroom setting should allow for one student per computer with Internet access as well as a projector and computer for the teacher.

1.4. Organization of the Dissertation

This dissertation is organized into six chapters. Chapter One provides a motivation for the research, an overview of the study, and its contributions to the field.

Chapter Two reviews prior research findings on statistics education, including studies on pedagogical and learning theory to enhance the statistics education. It also focuses on the role and utilization of technology not only in statistics education but in general education.

Chapter Three is the pre-development phase for the integrated teaching and learning environment, SmartNote, proposed in this study. It examines

the functions of Learning Management Systems (LMS), and then discusses the functions which will be included and new functions that will be added.

Chapter Four suggests the model of design for supporting an integrated teaching and learning environment, and introduces the functions implemented.

Chapter Five introduces the applications of SmartNote and reports the findings of field through analyzing the learning history data and survey data.

Finally, Chapter Six offers a summary, discussion of research findings, the implications of these findings and directions for future research studies.

2. Literature Review

2.1. Conflict in the Statistics Classroom

There are many disturbances during teaching in the classroom. One of the most serious disturbances is that students are not absorbed in their work. Consider a college classroom where the teacher lectures using a blackboard or PowerPoint. A limited number of students furiously attempt to write down every word that appears on the blackboard or PowerPoint slides but most students are engaged in other activities such as talking with peers, playing with mobile phones or even taking a nap. In the case of a computer classroom, they are also engaged in other activities such as web surfing, internet chatting or even playing computer games. They are almost always ill-prepared for their classes, and are only interested in attendance and the final grade without really learning. Absenteeism increases after submitting assignments or midterm examinations and, even worse, several students drop the course. As a result, the teacher and students blame each other and conflict arises in the classroom. These problems are not new. Meyers et al. (2006) differentiated between two types of conflict, inattentive (passive) versus hostile (active), and listed the typical behaviors of each type of conflict as follows:

- Hostile behaviors: Disparaging the instructor, arguing with classmates, or actively disputing course requirements and their grades.

- Inattentive behaviors: Being late to class, engaging in side conversations, or acting apathetic and bored.

In addition to the above conflicts mentioned, other conflicts occur such as the cognitive differences between the teacher and students towards statistics in the statistics classroom. Students have attitudes and beliefs that statistics is difficult, abstract and an extension of mathematics (Gal et al., 1997; Cobb and Moore, 1997; Basturk, 2005).

Sorcinelli (1994) argued that troublesome behavior in the classroom continues ceaselessly because student offenses tend to be egregious and instructors are hesitant to challenge them. Sorcinelli (1994) also suggested some solutions in dealing with troublesome behavior in the classroom such as: (1) Defining expectations for student behavior at the outset; (2) Decreasing anonymity by forming personal relationships with students; (3) Seeking feedback from students; and (4) Encouraging active learning.

Cornelius-White (2007) showed that conflicts in the classroom are related to teaching methods through literature review. Also, he asserted that learner-centered model based on active learning is effective to decreasing classroom conflicts.

The importance of pedagogy has been emphasized in a considerable amount of literature as one of the solutions to resolving conflicts. However, many teachers in college have not been shown how to teach in the best way. In particular, it is natural that statistics teachers lack pedagogical knowledge because they are not all educational researchers. However, various studies to improve statistics education, including teaching method and learning theory, are ongoing.

2.2. Statistics Education Research

Until the early 1990s, studies on statistics education were carried out in diverse disciplines (e.g., psychology, science education, mathematics education, or in educational technology) rather than in the area of statistics education itself because the research base had not yet been established. The need for studies in statistics education increased as statistics gained popularity and recognition as an essential subject at all levels of education.

Over the last two decades, the foundation for statistics education studies has strengthened into the independent research area that it is today. As a result, in 2002 the *Statistics Education Research Journal* (SERJ) was established, and the statistics education discipline now has its first dedicated scientific journal in which to publish high quality research. In addition to SERJ, recent research studies related to statistics education have been published in conference proceedings such as *The International Conference on the Teaching Statistics* (ICOTS) (Garfield and Ben-Zvi, 2007; Zieffler et al., 2008).

The goals of statistics education research are to change the attitudes towards statistics, and to improve teaching and learning statistics. To achieve these goals, a large number of research studies have been conducted from various perspectives. Research studies related to statistics education can be divided into three categories: (1) Teaching and learning methods; (2) Using technology in statistics education; and (3) The evaluation of the teaching and learning methods suggested by researchers.

2.2.1. Teaching and Learning Methods

Many researchers have pointed out the shortcomings of traditional teacher-centered instruction, which merely conveys knowledge to students because it is difficult to develop the students' understanding and the ability to apply their knowledge practically. They also pointed out why students participate passively and that it is difficult to change attitudes, beliefs and misconceptions in a lecture-and-listen format. In order to overcome the shortcomings of teacher-centered instruction, they urged the reform of pedagogy, shifting from teacher-centered to student-centered (Snee, 1993; Garfield, 1995; Moore, 1997; Cox, 1998).

Numerous teaching and learning methods have been studied to change the attitudes towards statistics and to develop students' conceptual understanding of statistics. As a result, teaching and learning theories verifying their learning effects have been reported. However, the majority of teachers is not aware of such research. Since a teacher or a statistician is not a statistics education researcher, it is reasonable that he/she lacks knowledge of the pedagogy related to statistics education (Gafield and Ben-Zvi, 2008).

For instance, many statistics teachers at the college level have a belief that good teaching involves explaining statistical concepts clearly and trying to deliver the more knowledge than their students can learn. During the class time, the students just listen to the instruction without any practical component. Eventually, the students just memorize and apply what they have learned mechanically and without understanding (Gal et al., 1997).

"Constructivism" is the representative philosophy studied in the educational psychology while the representative learning theories to practice the philosophy are "hands-on experience" and "active learning" based on a student-centered approach. In the statistics education field, these education philosophy and learning theories were not systematized and introduced in educational terminology. However, some leading statistics educators such as Snee (1993) and Moore (1997) have implemented them in their own classes in their teaching experience.

Constructivists view students as bringing to the classroom their own ideas and material. Rather than 'receiving' material in class as it is given, students restructure the new information to fit into their own cognitive frameworks. In this manner, they actively and individually construct their own knowledge, rather than copying knowledge that is 'transmitted', 'delivered' or 'conveyed' to them. A related theory of teaching focuses on developing students' understanding rather than on rote skill development, and views teaching as a way to provide opportunities for students to actively construct knowledge rather than having knowledge 'given' to them (Garfield, 1995). The Constructivist approach in the statistics classroom is well documented in the paper of Mvududu (2005). An example of practice was the learning module of Han and Han (2005) to teach the simple random sampling using information and communication technology based on the constructivism.

As researchers' awareness of the reform pedagogy increases, some learning theories and assessment methods that aim to achieve this reform have been addressed in many research papers. In representative studies,

there are hands-on experiments and collaborative learning with small groups to stress active learning. Several researchers argue that such teaching methods enable students to change their attitude towards statistics, to engage in their learning and to improve the educational outcomes (Ransdell, 1997; Roseth et al., 2008).

In addition to the change in pedagogy, a change in the assessment of students' learning has also been urged. Alternative assessment techniques — such as portfolio assessment, self-assessment and peer assessment — suggested by researchers urging the pedagogy reform can evaluate the students' overall learning process more elaborately while traditional assessments such as testing students with multiple choice, fill-in-the-blank, matching questions and essays evaluate only the simple knowledge (Garfield and Chance, 1999; Garfield and Chance, 2000; Han et al., 2009; Lee et al., 2008).

There has been a proliferation of studies regarding teaching and learning methods in statistics education, and these studies have been integrated into recommendations for improving statistics education. The American Statistical Association (ASA) offers a set of six guidelines (Guidelines for the Assessment and Instruction in Statistics Education, GAISE) for teaching the introductory college statistics course (Everson et al., 2008):

1. Emphasize statistical literacy and develop statistical thinking.
2. Use real data.
3. Stress conceptual understanding rather than mere knowledge of procedures.

4. Foster active learning in the classroom.

5. Use technology for developing conceptual understanding and analyzing data.

6. Use assessments to improve and evaluate student learning.

The recommendations of GAISE may provide good direction for statistics teachers, and may really help students' learning if its recommendations are realized. However, the realization of these guidelines is very difficult. Also its guide to using technology is somewhat narrow. Recent advanced technology impacts changes in the educational environment as well as the social environment.

2.2.2. Teaching and Learning Using Technology

Technology, such as computers and networks, have been used to assist teaching and learning statistics. The use of Information and Communication Technology (ICT) has usually been used as Computer Aided Instruction (CAI) that focused primarily on the effective transfer of knowledge. That is, many teachers and researchers recognize technology as a teaching tool to facilitate learning statistics. Using technology in statistics education is categorized as follows:

- using statistical packages;
- web based data collection tools;
- simulation tools;
- electronic textbooks; and
- miscellaneous.

1) Using Statistical Packages

Statistical packages for data analysis, such as SAS, SPSS, Minitab and R, became fashionable in the reform of statistics education, and have been used continuously in the statistics classroom. Basturk (2005) noted that SPSS is an useful tool for teaching an introductory statistics course. His findings suggested that students' learning capacity of the introductory statistics could be successfully improved when CAI is used as a supplement to a regular lecture in teaching introductory statistics course.

Although statistical packages allow students to easily analyze data, these packages were not designed for pedagogical purposes. Consequently, they do not provide definitional formulae to students who require more time to acquire them (Brooks and Raffle, 2005).

2) Web Based Data Collection Tools

Students who deal with real data as an integral part of learning statistics can gain still greater "ownership" of the data if they participate in generating it (Velleman and Moore, 1996). Collecting and using real data in statistics classes has long been emphasized but it is not easy to collect and use real data. To overcome the difficulties of using real data, Schwarz (1997) designed a web based sample survey and used the real data that students collected through collaborative work. It is meaningful in reducing the time and costs involved in collecting the data. It is also significant in the sense that real data from a census file to illustrate sampling schemes and concepts was used in the class.

3) Simulation Tools

Students experience difficulties in learning statistics due to beliefs they have that statistical concepts are too complex and abstract to learn. To resolve this problem, a large number of researchers have attempted to reinforce or deepen students' conceptual understanding of the course's complex topics by visualizing statistical concepts. One such attempt is in the use of computer simulation tools. These studies have increased exponentially with web development. In particular, Java applets (such as histogram, chance game, confidence interval, and simple regression line) addressed by West and Ogden (1998) are simulation tools for hands-on experiments on the web. Their study influenced a number of subsequent studies. There are now too many similar Java applets on the web. A Google search for "Java Applet Histogram" returns nearly 170,000 hits. In order to avoid re-inventing the wheel and to improve cost-effectiveness, Mittag (2002) stated that we need to promote systematic international multimedia cooperation between educational institutions.

While numerous Java applets have been developed to improve students' motivation to learn and stimulate interest, some researchers raised questions about the quality and the learning effectiveness of them. Ahn et al. (2005) pointed out that students tend to just click buttons without thinking about what they are seeing.

4) Electronic Textbooks

With advancements in the internet, several electronic textbooks (such as

HyperStat, CyberStat, Seeing Statistics, etc.) have been developed. The main advantage of electronic textbooks is clearly their interactive nature that allows students to actively learn statistics. Yet, interactivity still needs to move beyond animated representations and provision of ready-made feedback. It needs to be complemented with adaptive feedback and scaffolding tailored to the students' individual needs (Larreamendy et al., 2005). In addition to interactivity, Symanzik and Vukasinovic (2003, 2006) cautioned that an electronic textbook should not be used alone, but should be accompanied by a printed book and optionally with the other electronic format.

5) Miscellaneous

There were various attempts to enhance statistics education via advanced technologies. The prominent results of such attempts are Java applet and electronic textbook. However, the common deficiencies of Java applets and electronic textbooks are no way to monitor how students learn and the difficulties of feedback.

Java applets and electronic textbooks have continued to be unnecessarily even now. These course materials are more pedagogical than those of the late 1990s. Also, these course materials better use the recent technology than ever before. There are typical products such as SOCR (Dinov, 2006; Chu et al., 2009; Dinvo, 2009) and STATLAB (Rijpkenma et at., 2010). It is meaningful that SOCR (Statistics Online Computational Resource) integrated many other web-based tools scattered in cyber-space as collections. SOCR has numerous tools providing hands-on experiments via

computer simulation and learning activities using Wiki. However, SOCR has no function to identify individuals so it seems unable to understand who, when, how and where students learned or learn.

STATLAB is an interactive web-based tool for teaching Design of Experiments. Students learn through experience in its virtual environment and can receive direct feedback to their learning. Also, the results of the students' learning activities is sent to the teacher via email and can be used for grading. Although STATLAB has several benefits, it is insufficient to cover general topics for statistics due to its focus on Design of Experiment.

While Java applets have been developed for interactive teaching materials, they cannot be used to create highly effective learning activities without having advanced skills in programming. As an alternative to Java applets, Hunt and Tyrrell (2000) suggested an interactive spreadsheet using Microsoft Excel. A similar study was completed by Hagtvedt et al. (2007, 2008) who developed simulation tools for Sampling Distributions, Central Limit Theorem and Confidence Interval. They argued that such simulation tools could enhance students' understanding for each concept.

When comparing a Java applet (as shown on the left of Figure 2.1) and an interactive spreadsheet (as shown on the right of Figure 2.1), there is no difference in the design concept although there is a difference in the development environment. Users can adjust the confidence level by slider and create the confidence intervals from new simulated data set through pressing the 'More Interval' button in the Java applet. As a similar way, users can graph the confidence intervals by pressing the 'Run Again!'

button in the interactive spreadsheet. As early noted, these activities may give greater insight to the confidence intervals of students; however, there are almost no way to identify students' comprehension.
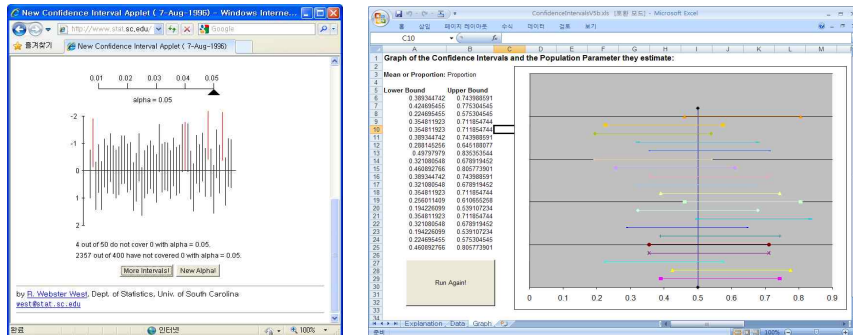
Figure 2.1: Java Applet versus Excel Interactive Spreadsheet for Confidence Interval

As the use of the computers and internet has increased in the classroom, a new issue that arises is that it is now easier for students to copy the work of others and present it as their own. In order to combat plagiarism, several researchers suggest individualized homework assignments as follows:

- Providing individualized random dataset and homework using Excel (Hunt, 2005; Hunt, 2007a; Hunt, 2007b).
- Automatic generation of exams and providing random dataset using R (Grün and Zeileis, 2009; Shutes, 2009).
- Combining random number generation and portable document format files via LATEX (Dryver, 2009).

Although those studies could combat plagiarism and facilitate

self-learning, there are also problems that mainly focus on the evaluation of learning.

2.2.3. Evaluation of Teaching and Learning Methods

As previously stated, the range of research related to statistics education is very wide. A wide range of research is relevant for improving statistical practice and statistics education, but this research is too fragmented to be used effectively. Therefore, practitioners and teachers should be able to justify their chosen techniques by taking into account research results: This is evidence-based practice (EBP). In other words, statistics education and its research should be made through the practice of evidence-based (Beyth-Maron et al., 2008).

Several researchers insist that leaning through hands-on experiments, computer simulation and using technology could improve student learning. Some researchers argue, however, that such teaching strategies have no learning effects.

Mills (2002) reviewed the literature on how computer simulation methods are used in the statistics classroom, and pointed out that there has been very little empirical research. Unlike most researchers, she noted that the effect of computer simulation methods is unclear. Lunsford et al. (2006) created a classroom research model to investigate student understanding of sampling distributions of sample means and the Central Limit Theorem in post-calculus introductory probability and statistics courses. They saw that they could not expect students to have good graphical interpretation, comparison and reasoning skills concerning

sampling distributions even if students understood the basic theory and were able to perform computations using the theory. They argued that just demonstrating graphical concepts in class via computer simulation is insufficient for students to develop these skills, and they recommended that students need to have a directed (either through an activity or an exercise) hands-on experience with computer simulations. According to Plaff and Weinberg (2009), their hands-on activities generally failed to help students develop a good understanding of the underlying statistical concepts. They emphasized the importance of empirical study to determine the effect of pedagogy:

> *No matter how innovative or stimulating a pedagogical idea may seem − and no matter how much the students seem to enjoy the class − it may not be sufficient to develop students' understanding. Numerous articles are published every year describing activities, pedagogical tools, and techniques that the authors believe will increase student understanding and engagement. However, it is imperative that these pedagogical innovations are tested.*

Unlike these arguments, Dinov et al. (2008b), through an empirical study using SOCR, insisted that technology-based instruction can enhance the learning effectiveness, and that it represents a new recent pedagogical paradigm that is rooted in the realization that new generations are much more comfortable with, and excited about, new technologies. Watson and

Donne (2009) agreed that using technology-based instruction can improve students' understanding though software itself does not seem to provide a solution.

Although there is no consensus of opinions among researchers, there is also no disagreement. In recent years, many research studies have provided empirical evidence to determine the learning effects and their subjects are to use technology effectively to improve student learning. This can be interpreted that many researchers have recognized the importance of technology.

2.3. Role of Technology in Statistics Education

With the rapid advancements in technology, the classroom environment is constantly changing. Recent technology such as Wireless Internet, Touch Pad and Smart Phone will change the classroom environment even more. Therefore, it is necessary to review the value of technology and its role in statistics education.

As reviewed in Section 2.2, there are different views on the use of technology. However, it is hard to imagine teaching statistics today without using some form of technology. The technology revolution has had a great impact on the teaching of statistics, perhaps more so than many other disciplines (Chance et al., 2007). Chance et al. summarized the role of technology in improving student learning of statistics:

- Automation of Calculation;
- Visualization of Abstract Concepts;

- Simulations as a Pedagogical Tool;

- Investigation of Real Life Problems; and

- Provision of Tools for Collaboration and Student Involvement.

They emphasized that technology has a great potential to enhance student achievement and teachers' professional development, and it will most likely continue to impact on the practice and teaching of statistics in many ways. However, they warned that technology has an impact on education only if it is used appropriately.

Although Chance et al. (2007) summarized the role of technology inclusively, they only focused on using technology to improve student learning. Thus, they recommended using restrictive technology. Velleman and Moore (1996) pointed out that computing has had a greater impact − at least in the teaching of statistics − but that it has supplemented rather than replaced traditional classroom practice. Even today, perceptions of the role of technology have not changed significantly in statistics education. For example, there have been a considerable number of studies to improve students' understanding. However, there are almost no studies on learning management: How students learn, how students understand and how long they spent with learning. Ahn et al. (2005) suggested using various technologies in web-based education. In particular, they stated the importance of the practical use of the learning data to observe documented learning behaviors and emphasize the use of Database technology for collecting and analyzing the learning data. Their suggestion is very persuasive; however, it is difficult to find such a case in statistics

educational research.

2.4. e-Learning in Statistics and LMS

It is necessary to review educational studies more generally because it is difficult to find an integrated study on supporting pedagogy, improving students' understanding and learning management. This section provides a review of e-Learning, integrated teaching and learning environment. Learning Management System (LMS), the infrastructure of e-Learning systems, is also examined in this section.

The study of e-Learning is very broad and its definition is wide. Härdle et al. (2006, 2007) provided the following definition: "E-learning describes all kinds of learning, where digital media are used for the presentation and transmission of learning materials and/or to support inter-human communication." They grouped e-Learning tools as follows:

- video conferencing and tele-teaching systems;
- simulations with or without user interaction;
- learning (content) management tool;
- content catalogues and podcasting; and
- web and computer-based training application.

Härdle et al. (2006, 2007) showed skepticism towards e-Learning. The reason for doing so is that the utility of e-Learning is not clear, and their students prefer print media (e.g., books) to electronic media.

In contrast, Nolan and Temple Lang (2007) proposed a system for

interactive and dynamic documents which allows students to follow the complex decision making processes of a statistical analyst. To develop their system, they used various technologies related to computing. However, despite integrating several computing technologies as a dynamic document, they overlooked the aspect of learning management.

Self-directed learning or student-centered learning is important: The teacher cannot expect to achieve his/her goal unless the students' self-regulation and instinct motivation are strong even if the e-Learning system can support innovative pedagogical tools. Hence, the intervention of the teacher should be required for effective e-Learning (Symanzik and Vukasinovic, 2003; Delialiogla and Yildirim, 2007; Schuyten and Thas, 2007).

In the mid 2000s, there is a remarkable innovation in the web. In the past years, most users lacking skills to write a web page were just consumers, and they could not be involved in authoring web pages. However, since Web 2.0 was introduced by O'Reilly (2005), users have moved from being readers or consumers to being producers with far more influence than ever before. Web 2.0 websites allow users to do more than just retrieve information. The core philosophy of Web 2.0 is "participation", "sharing", and "openness". Web 2.0 has impacted on e-Learning and researchers have been attempting to evolve to e-Learning 2.0. As Web 2.0 spread, social software such as Blog and Wiki became popular. Accordingly, the use of Blog and Wiki in the classroom has increased.

Luehmann and Frink (2009) pointed out that Blog has been used inefficiently through their case study of nine classroom blogs for two

reasons. The first is that Blog was not designed for pedagogical purposes. The second reason, as Strasuss (2005) mentioned, is that teachers are not welcoming the rapid change in technology. Brescia and Mille (2006) contradicted themselves by pointing out that there has been no empirical study on the value of pedagogical use of Blog, and then arguing that the pedagogical use of Blog is valuable in improving student learning.

In recent years, Wikipedia, a Wiki-based encyclopedia using collective intelligence, has increased in popularity. Also, use of Wiki has been increasing in statistics education. Ben-Zvi (2007) used Wiki to assist in collaborative learning. He argued that Wiki is useful for helping collaborative activities and collaboration can improve the learning of each individual in the statistics classroom as well as the whole class. He presents several types of Wiki-based activities: collaborative writing, glossaries, discussion and review, statistical projects, self-reflective journals and assessment. Wiki has also been used in StatCrunch, a pedagogical statistics package for analyzing data, sharing and discussing data and its analysis results (West, 2009).

Though Blog and Wiki have much educational potential, this software also has some limitations. Above all, Blog and Wiki have no learning management functions. Therefore, this limitation may mean a heavier workload of assessments for teachers as learning activities are increased.

Most teachers want to reduce the efforts of teaching and efficiently manage to increase time for their research. Learning Management System (LMS) were developed to manage students learning and their human resources automatically. Consequently, most colleges now have their own

LMS within the infrastructure of e-Learning or Blended Learning. While there are several definitions of LMS, the basic description is a software application for the administration, tracking and reporting of training events (Ellis, 2009).

While there are several LMSs, two representative LMSs are Blackboard and Moodle. Blackboard is commercial software while Moodle is an open source software. Since Moodle is an open source software, it is available free of charge. Furthermore, the features of Moodle are better than those of Blackboard, and students prefer Moodle to Blackboard. Consequently, the users of Moodle are constantly increasing (Brandle, 2005; Machado & Tao, 2007). Detailed features for LMSs can be compared and contrasted via EduTools (http://www.edutools.info).

Research on how LMS affect teaching and learning of statistics is scarce. Aguilera et al. (2010) facilitated student-directed learning through using Moodle and introduced its application examples in an advanced statistics course as follows:

- Didactic guide with the syllabus and the information related to the course.
- Notes of the theoretical contents in both PDF and HTML format.
- Examples of real data applications carried out by using appropriate statistical software.
- Self-learning tutorial: guides for independent work with a series of activities (readings, short questions, application exercises, web search, etc.) that students will do, based on the resources provided by the

teacher, to learn for themselves.

- FORUM and CHAT where the students discuss their responses and questions related to the activities proposed in the self-learning tutorials.

- Self-assessment quizzes and evaluation activities.

- Other learning resources such as reading material, real data sets, and links to outside resources.

- A notice board for up-to-date course information.

- E-mail that allows personalized communication between teacher and students.

LMS can make easy deployment and management of learning materials and is a valuable tool for student management. However, it is not enough to manage the more sophisticated learning procedure and status (e.g., frequent mistakes, learning time, deficits in learning, etc.). In order to effectively manage the learning procedure, LMSs need to add features to collect and analyze the learning occurred in learning process.

2.5. Learning History Data

Along with the prevalence of LMS, there is an increase in the automatic analysis of the usage data to the system. Several researchers have analyzed the web-log data and contents usage data stored by LMS. Most researchers apply Data Mining techniques to analyze the data because the data is so big. Based on the analysis results, they attempt to develop a more intelligent LMS that could provide adaptive learning environment and

appropriate feedback to students (Garia et al, 2007; Romero et al., 2008; Xie et al., 2010).

Commercial systems such as WebCT, Blackboard and LearningSpace already give access to some information related to the activity of the learners including some statistical analyses, and provide teachers with information on course attendance and exam results. With this information already being useful, it only represents the tip of iceberg of what might be possible by using advanced technologies. To automatically analyze learner interaction, it needs to collect more pedagogical data not based on just click through data according to Muehlenbrock (2005).

Matsui and Okamoto (2003) used learning history data (LHD) to effectively assess the learning process under the e-Learning environment. Ueno (2005) also defined e-Learning History Data to develop a LMS with intelligent agent to provide effective adaptive messages to a learner. The variables of LHD considered by Ueno are as follows:

1. The number of contents that the learner has learned.
2. The number of times the learner has accessed the e-Learning system.
3. The average number of the times the learner has completed each content.
4. The average learning time of each lecture which consists of several contents corresponding to a 90 minute lecture.
5. The average degree of understanding of each content.
6. The average learning time of each course which consists of fifteen lectures.
7. The average number of times the learner has changed his/her answer

to the questions in the e-Learning.

8. The number of times the learner has submitted his/her opinion to the discussion board.

9. The average learning time for each content.

LHDs used by some studies make sense in that teachers could observe students' learning status and use the information for feedback. However, since these LHDs are insufficient to grasp students' cognitive process, their difficulties in learning and deficits in learning, it needs to collect LHDs by atomizing learning process per unit of learning behavior (Mun et al., 2007).

In summary, a major cause of conflict in the classroom is the teaching method. The traditional teacher-centered instruction method has been pointed out in many research studies since this teaching method makes it difficult to encourage students' involvement and to expect to develop students' understanding. There have been a considerable number of studies to enhance statistics education including teaching and learning methods, even though most teachers in statistics course do not know enough about statistics educational studies. Several researchers argued that the teaching methods such as hands-on experiment and active learning enable students to improve their conceptual understanding and to change their negative attitude towards statistics.

Unlike the opinion, some researchers argued that the learning effect of suggested teaching methods is not clear. They also argued that there have been few empirical studies to verify the learning effects. The best way to verify the learning effect is to adopt suggested teaching and learning methods in teaching practice. However, there has no study on providing

teaching and learning environment to apply pedagogies and learning theories easily nor has there been a study and environment in general education fields. Therefore, a study on integrated teaching and learning environment providing a connection between research findings and teaching practice is urgently needed.

3. Functional Approach to LMS and e-Learning Tools for Statistics Education

This chapter is a pre-step to develop SmartNote, the integrated teaching and learning environment proposed in this study. It gives an overview of the major features and the design philosophy of Moodle that is one of the representative LMSs. In particular, it includes a discussion of the advantages and disadvantages of Moodle, and examines the functional features included in and newly added to SmartNote. It then compares SmartNote with other e-Learning tools for statistics education.

3.1. LMS

As discussed in Section 2.2, the typical LMSs are Blackboard and Moodle. In addition, several LMSs like WebCT, Sakai, and ATutor exist. Blackboard and WebCT are commercial LMSs and WebCT was merged with Blackboard as the Course Management System. Moodle, Sakai and ATutor are the open source LMSs and they are being used increasingly for free, available software. Figure 3.1 (Zacker's blog) shows that the market share of Moodle is superior when compared to other LMSs.
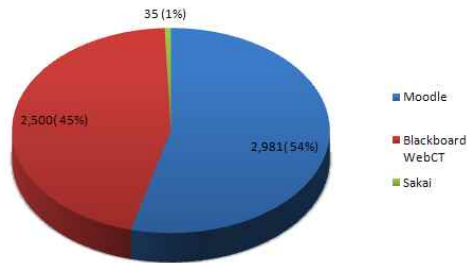
Figure 3.1: Higher-ed LMS Market

The world market share in Moodle is high; in the domestic (South Korea) market, however, it is believed to be very low (http://moodle.org/sites/). Currently 132 Moodle websites are hosted in the domestic market, and most show that Moodle is used for research or personal purposes rather than to integrate course management at university level. The reason for this is the belief that local users should be responsible for everything, from the installation to management, and should have a more advanced knowledge of computing than just installing and managing a program despite the advantages of Moodle, which is free and has no license costs. However, the use of Moodle in colleges and universities is increasing steadily as shown in Figure 3.2.
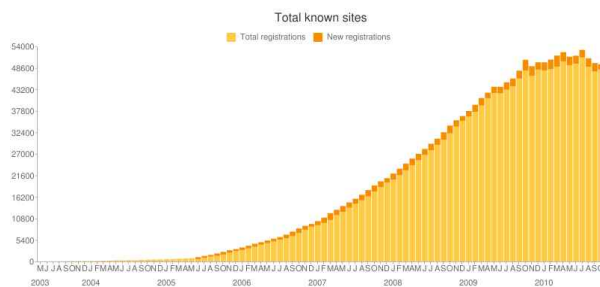
Figure 3.2: Moodle Deployment Statistics

Further statistical information for Moodle is available at http://moodle.org/stats. The design philosophy and features are also well-organized in Cole and Foster's (2008) book, *Using Moodle*.

Moodle was created by Martin Dougiamas, a computer scientist and educator. Since Moodle's original release, a large number of developers and the Moodle community have worked to update the program with newer versions: Moodle 1.0 was released in 2002 while Moodle 2.0 is the most recent version of Moodle. Moodle was born from the design philosophy of social constructivist practice. As a result, it is well-equipped with tools to support collaborative learning such as: Forum, Discussion and Chat. Moodle provides the following representative tools:

- Uploading and sharing materials;
- Forums and chats;
- Messaging;
- Quizzes;
- Gathering and reviewing assignments;
- Recording Grades;
- Attendance Book;
- Wiki;
- Blog;
- Database; and
- Survey.

Teachers can enhance students' learning through tools that allow

teachers to upload and share learning materials. These tools are necessary for supporting teaching and learning.

For example, Forum and Chat are meaningful in the sense that they provide a discussing space and a variety of channels for communicating between the teacher and students. However, it cannot be guaranteed that students will actively participate in such discussions. Communication using Forum is asynchronous communication that can only be checked after a period of time. Therefore, if the students do not have access to the Moodle site, learning may not proceed as the teacher intends. In particular, a problem with students' lack of motivation may result in them not even accessing the system. While Forum is a tool that supports asynchronous communication, Chat is a tool that supports synchronous communication. However, students can only access Moodle to use Chat, and it is overly restrictive. Since students prefer to send short text messages via mobile phones or use popular chat programs like MSN or NateOn, the effectiveness and success of Moodle Chat cannot be guaranteed. Similarly, students prefer to use the popular Blog and Wiki but these tools are not enough to facilitate learning since most of content is about the private lives of the authors.

Moodle's Quiz offers students two types of quizzes, multiple choice and short answers, for self-learning and self-assessment. It is a useful tool because it provides students with immediate feedback and also helps the teacher understand students' learning. However, it is unlikely that students will answer the quizzes sincerely each time. In addition, identifying students' understanding with such quizzes in subjects such as statistics,

which requires mathematical logic, is not enough.

Tools that aggregate and review homework done by students are essential tools in teaching and learning. It is an advantage that assignments submitted by students can be shared easily in an online environment unlike in a paper-based environment. Hence, a function that enables a teacher to share student assignments as well as aggregate and review them is expected to be a useful tool.

Moodle Gradebook can be used not only to manage grades for a course but also to calculate grades, communicate expectations and provide prompt feedback to students. Hence, it is a useful tool that can reduce the workload of teachers relating to assessments. Also, since the Moodle Attendance tool can automatically manage student attendance, it gives teachers more free time.

Moodle Database is a tool for creating shared collections of data. Since collected data is effectively used in a statistics classroom, it is certainly useful although not essential. Moodle Survey is also a valuable tool that helps teachers to collect student feedback regarding students' understanding of content and satisfaction in their learning.

Moodle provides various other tools in addition to those mentioned so far. However, since many tools are functionally similar tools that do not differ greatly, they will not be cited.

The biggest advantage of Moodle, and the biggest drawback, is that it provides too many tools. This makes using Moodle more confusing, and may be a greater barrier in learning to use Moodle for both teachers and students. The Moodle Teacher Certificate (MTC), written in the community,

evaluates the skills of using the Moodle. This, on the one hand, means that there are enough Moodle users to require the presence of such certification. On the other hand, this reveals that using Moodle is difficult and complicated. One of the biggest problems with Moodle is that students must request, via e-mail, to be enrolled in the Moodle course; this request can only be made when the teacher allows for students to request enrollment in the class. Consequently, this may be an obstacle to learning management since students may not be enrolled in the Moodle course even if they are actually enrolled in their course.

Above all, the most vulnerable of the functions of Moodle is the function to assess students' understanding and learning behavior although Moodle offers several functions regarding course management and student management. In order to clearly understand students' comprehension and behavior, content and LMS should be able to interact with each other. Moodle, however, considers only content management and its distribution. In the design of the new approach, content and the LMS are able to interact with each other (as shown on the right of Figure 3.3) to understand students' comprehension and learning behavior. To do this, a method to collect learning history data and its use should be considered.
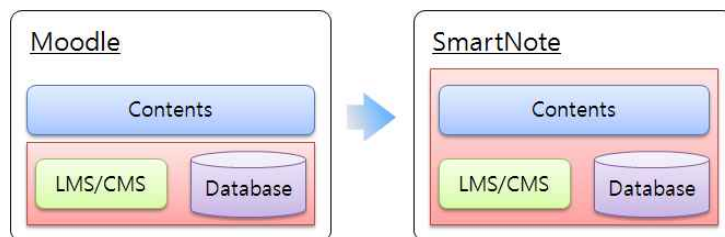

Figure 3.3: Comparison with Moodle and SmartNote

SmartNote integrates similar features of LMSs like Moodle into one feature that makes it easy for both teachers and students to use. In addition to the basic features of a LMS, SmartNote focuses primarily on additional features to support several pedagogical approaches and efficiently grasp students' learning behavior. SmartNote will implement the following tools:

- Course management;
- Uploading and sharing materials;
- Gathering, reviewing and sharing assignments;
- Learning History Data Collection/Analysis;
- Collaborative Learning;
- Attendance Book; and
- Survey & Data collector.

The design and implementation of SmartNote will be discussed in detail in Chapter Four.

3.2. Comparison between Moodle and SmartNote

If the tools listed in Section 3.1 are implemented, SmartNote could be compared to Moodle in three perspectives: Supporting tools for course management, learning activities and understanding students' comprehension.

The first perspective of comparison between Moodle and SmartNote in supporting tools for course management is shown in Table 3.1. The

perspective of course management can again be divided into three categories: Course management, student management and course material management. In course management, there is no difference in features between Moodle and SmartNote. However, there are several differences between them in student management and course material management.

Table 3.1: Supporting Tools for Course Management

Category	Features	Moodle	SmartNote
Course	Registration	Support	Support
	Information Modification	Support	Support
	Time Schedule Management	Support	Support
Student	Enrollment	Support	Support
	Dropping-Out	Support	Support
	Profile Modification	Not Support	Support
	Attendance Management	Partial-Support	Support
Course Material	Composing	Support	Support
	Importing	Support	Not Support
	Exporting	Support	Not Support
	Using Content Model	Not Support	Support

The distinctive differences in student management are the student's profile modification and attendance management. Teachers may modify students' profile with regard to things like gender, previous semester credits, etc. and this capability will be helpful for generating homogeneous groups on collaborative learning by students' quality. Also, there is a unique and primary difference in attendance management. In the case of using Moodle, teachers should check student's attendance which is time-intensive when classes are big, while SmartNote will allow students and the teacher to check attendance. In course material management,

Moodle allows teachers to import and export course materials in several formats while SmartNote allows them to use the dynamic content models. The reason for this is that SmartNote focuses on supporting the interaction between LMS and contents as well as deploying the contents.

The second perspective is a comparison between Moodle and SmartNote in supporting tools for learning activity as shown in Table 3.2.

Table 3.2: Supporting Tools for Learning Activity

Type	Features	Moodle	SmartNote
Individual	Static Contents	Support	Support
	Dynamic Contents	Partial-Support	Support
Collaborative Learning	Generating Groups	Manually Support	Automatically / Manually Support
	Role Management	Not Support	Support
	Supporting Self-Study	Not Support	Support
	Group Assessment	Not Support	Support
	Peer Assessment	Partial-Support	Support
	Group Activity Journal	Partial-Support	Support
	Outcome Management	Partial-Support	Support
Collaborative Working	Data Collection	Partial-Support	Support
	Data File Download	Support	Support

Both Moodle and SmartNote provide an individual/collaborative learning environment for students; however, there are many differences. Moodle provides dynamic contents for self-learning and exam preparation with Quiz which uses randomly shuffled and ordered problems in a test bank. Whereas these features are good for providing individualized contents, they are insufficient for leading thoughtful self-learning. For example, students have a tendency to simply click an answer choice without any thought. To

overcome this limit, SmartNote will use the dynamic contents model and it will be able to scan students' thinking process so that they have to study seriously.

There are a lot of differences between Moodle and SmartNote in supporting collaborative learning. Though Moodle offers Forum, Chat and Messaging for collaborative learning, they have difficulty in managing collaborative learning. SmartNote will complement the shortage by adding several functions such as 'Generating Groups', 'Role Management', 'Group Assessment' and so on. As mentioned earlier, it is important to use real data in the statistics classroom. Moodle provides Database and Survey to collect the data; however, the data type is not suitable for data analysis. Therefore, SmartNote will design a data collection tool so that teachers can plan to collect data with various scales such as nominal, ordinal, numeric and open-ended.

The third perspective is a comparison between Moodle and SmartNote in supporting tools for learning activity management as shown in Table 3.3.

Table 3.3: Supporting Tools for Understanding Students' Understanding

Type	Moodle	SmartNote
Grading	Support	Partial-Support
Learning History Tracking	Partial-Support	Support
Assignment Performance	Support	Support
Students' Understanding	Partial-Support	Support

The Grading Book is a useful tool for teachers and students, and the grade is a reward for students for their learning time and efforts. However,

SmartNote will focus on learning history tracking and understanding students' comprehension. Moodle provides several tools related to these. However, their functions are deficient in calculating the learning time and tracking the process of thinking.

3.3. e-Learning Tools for Statistics Education

As mentioned in Section 2.2 and Section 2.4, e-Learning tools for statistics education have been developed without considering an integrated teaching and learning environment. Most e-Learning tools are multimedia-based electronic textbooks like ActiveStats (Velleman, 2000) and Java applets for specific topics. The e-Learning tools for statistics education are well-organized by topic at the Resource of CAUSE (http://causeweb.org).

Ongoing research in SOCR (Dinov et al, 2008a; Dinov et al, 2009) provides tutorials and activities using Wiki as well as applets for explaining statistical concepts, computer simulation tools, etc. by relatively recent technology integration(see Figure 3.4, 3.5). SOCR may be appropriate as a tool for explaining or conveying statistical concepts. However, it is difficult to expect it to efficiently manage data generated in classroom because SOCR does not use a Database Management System (DBMS).

SmartNote has a different perspective from those of existing e-Learning tools for statistics education. It does not seek to re-write multimedia materials such as applets or flash movies but provides an environment to be able to use the existing materials through integration. The main purpose for providing such an environment is so that teachers can easily implement good pedagogical approaches in their classrooms.
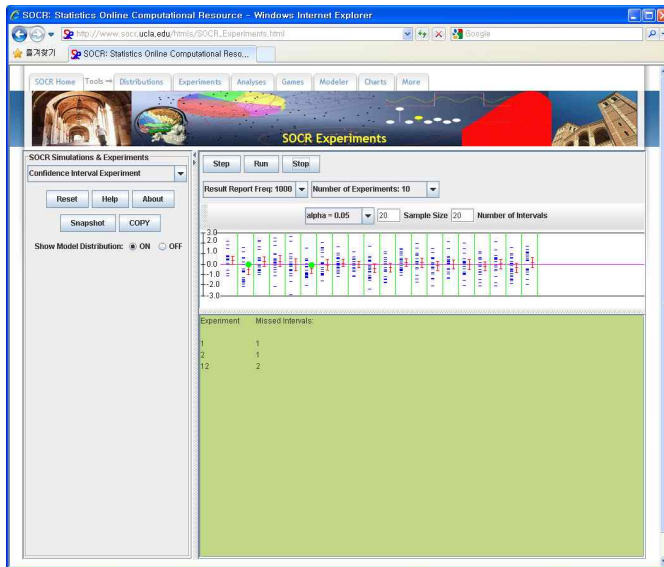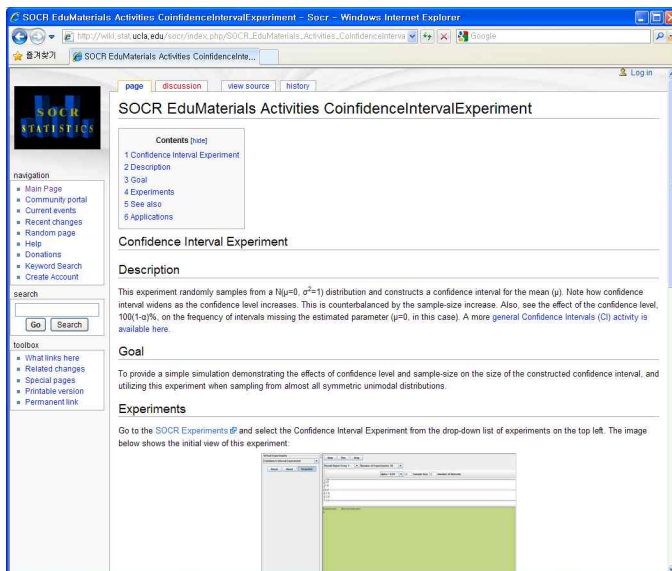
Figure 3.4: SOCR Experiments

Figure 3.5: SOCR EduMaterials Activities
Confidence Interval Experiment

4. Design and Implementation of SmartNote

Chapter Four develops the design model of SmartNote based on the design philosophy and tools required for an integrated teaching and learning environment; it also summarizes these design principles. Next, it addresses the structure of the Learning History Data (LHD) generated during learning activities and how to efficiently collect and use these practically. Then it designs a computational framework, and summarizes the environment and tools for needed for its development. Finally, it highlights its user-specific features and modules.

4.1. Design Model of SmartNote

Figure 4.1 illustrates the design model of SmartNote. This model is able to support both teachers and students because it is possible to fuse pedagogy, content and technology to reflect a variety of teaching experience and research results.
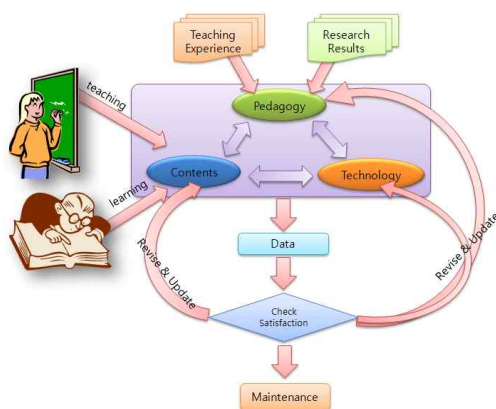

Figure 4.1: Design Model of SmartNote

Data of teaching practices and learning activities are automatically stored in the system and the analyzed results are sent to the teacher and students. Teachers can understand students' comprehension from the results, and provide them with immediate feedback. Also, students can diagnose their own learning status since they are able to see the results immediately, and receive systematic feedback to facilitate active learning activities and help them not lose motivation. In addition, the results enable teachers to determine whether to maintain or revise the pedagogy, content and technology used in classroom after checking student satisfaction. Therefore, there are several advantages in that various pedagogies, various forms of content and various technologies are able to coexist and the teaching model can be changed at any time based on the requirements of users (teachers and students) and the analysis of their usage data.

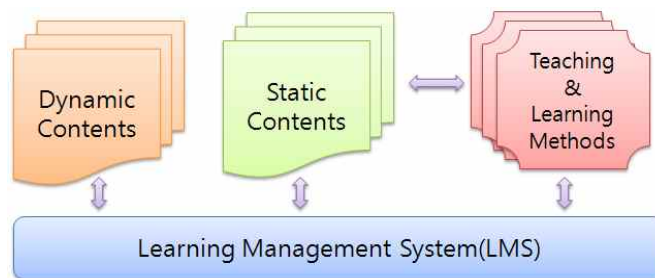Figure 4.2: Teaching and Learning Environment

The teaching and learning environment is illustrated in Figure 4.2, combined with the design model in Figure 4.1, will be very helpful in improving teaching and learning because it is possible to quickly collect and analyze learning data and give individually tailored feedback through the latest computing and ICT. However, as Moore (1997) emphasizes, the

thing to remember is balance among pedagogy, content and technology and their synergy although using advanced computing and ICT. SmartNote is an integrated teaching and learning environment that implements Moore's argument, and provides a model for linking research findings to teaching practice in statistics education.

4.2. Design Principles

To develop SmartNote, the following design principles were considered:

- to allow various pedagogies, learning theories and contents to coexist;
- to accept changes in society and technology;
- to be able to collect and analyze LHD;
- to support student participation, share and be open to learning outcomes;
- to support tools for students management and course management;
- to support tools for investigation to the state of use and class satisfaction; and
- to provide various roles and individualized interface or views depending on these roles.

These design principles are essential for SmartNote to maintain its flexibility by accepting social and technological changes without being limited to specific pedagogy, content and technology. They are also key elements for the possibility of SmartNote's continuous evolution.

4.3. Practical Use of Learning History Data

4.3.1. Structure of Learning History Data (LHD)

As mentioned in Section 2.5, LHD should be collected by considering content types such as summarizing of body, examples, exercises and quizzes, and learning activities such as in-class and out-of-class. Also, LHD such as correct answers, students' answers and scores should be collected in order to provide appropriate feedback to students. Correct answer will be awarded 1 point while incorrect answers will receive 0 points. Scoring is determined by the difficulty of the content which makes it difficult to determine the scoring before the LHD is collected and analyzed. Therefore, depending on the teacher's experience and subjective judgments, the initial scoring rule cannot help. If the LHD is stored, however, this rule can be modified. Table 4.1 shows the structure of the LHD:

Table 4.1: Structure of the LHD

Attribute	Data Type	Description
User	String	student number
Saved Date	String	saving in millisecond
Access IP	String	internet access address
Subject ID	Discrete Number	
Content ID	Discrete Number	
Content Type	Discrete Number	example, exercise, quiz, etc.
When Learning	Discrete Number	in-class, out-of-class
Correct Answer	String/Number	
Student Answer	String/Number	
Score	Discrete Number	correct:1, incorrect: 0

LHD that consists of these variables can provide useful student activity information such as who, when, what content, where and how. It can also afford additional information such as where students generally made mistakes and reasons for these mistakes.

4.3.2. Learning History Data Collection Method

The LHD in Table 4.1 should be collected automatically. Since the data collected in the LHD is large, the use of a Database Management System (DBMS) is essential for the handling of such data. Tools such as DBMS, LMS and Contents are required for the automatic collection of LHD. Above all, the tool that enables learning activities to collect learning history by the unit is content. Therefore, the question of how to design high-quality learning content for LHD collection is an important factor.

Content must be equipped with features and data collection capabilities as well as simply function as a medium for knowledge transfer. Content should be distributed to students through a LMS for their learning and supported User Interfaces (such as keyboard input, mouse click and mouse drag) for various interactions with students. Figure 4.3 depicts the content and LHD stored in the database. Students fill in the blanks with their own answer after solving problems in content and receive feedback related to whether or not the answers are correct. Correct answers will be highlighted. If the content is incorrect, an error message will appear and the blank space will again be initialized.
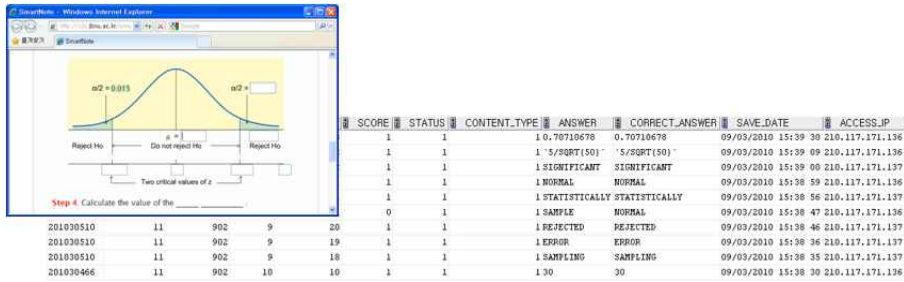
Figure 4.3: The Content and LHD Stored in the Database

The contents remain blank permanently in the case of an incorrect answer so that it can inform students about their learning progress when they next visit the site. The results of learning activities — that is, the events that occurred by students' learning in the content areas — are the incomplete data that are corresponded to the partial variables, such as 'Subject ID', 'Content ID', 'Content Type', 'When Learning', 'Correct Answer' and 'Student Answer', of LHD. The data generated in this way is sent to the LMS and the complete data, excluding the 'Saved Date' is saved in the database by adding additional data that the LMS provides such as 'User', 'Access IP' and so on. 'Saved Date' is saved by using the date that is saved in the database because the time saved in the database may differ to that of the client's computer (see Figure 4.4).
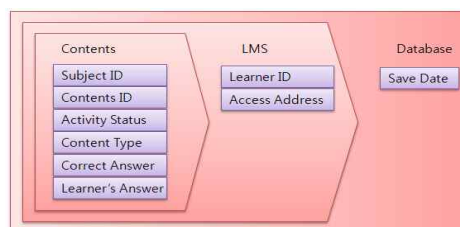

Figure 4.4: Saving Data in the Database

Figure 4.5 shows the whole process relating to the LHD collection method and the practical use of LHD. After choosing a teaching method, the teacher chooses the content that students have to learn. Students perform their learning activities via LMS and the results of these learning activities are sent to the LMS where the results are turned into LHD in the LMS and the LHD is saved in the database. The saved data in the database is then sent to the teacher and students who request it by processing information such as learning time by date or learning performance by section.
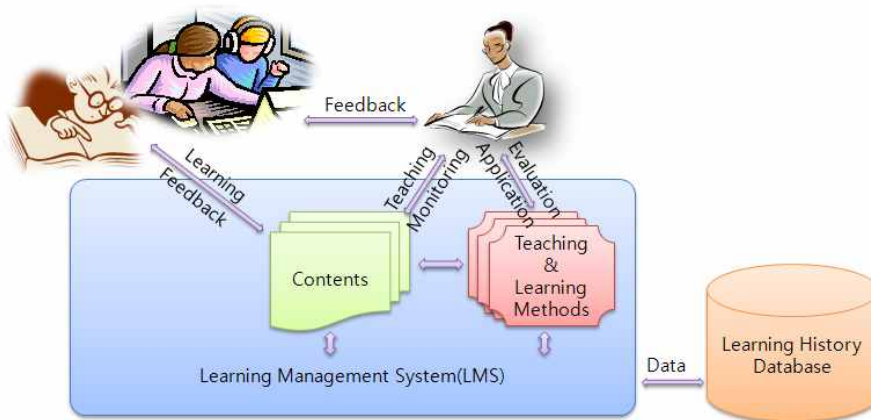
Figure 4.5: Saving and Processing LHD

If the content were provided to all students in uniform, dishonest students copying another student's assignment would exist and these data to identify the students' learning situation will not help at all. Therefore, it is necessary to provide individualized contents to students to prohibit collecting garbage data in advance. Content design and implementation is beyond the topic of this study, so a detailed description will be omitted.

4.4. Framework

4.4.1. Brief Framework

A brief framework for implementing SmartNote is shown in Figure 4.6.
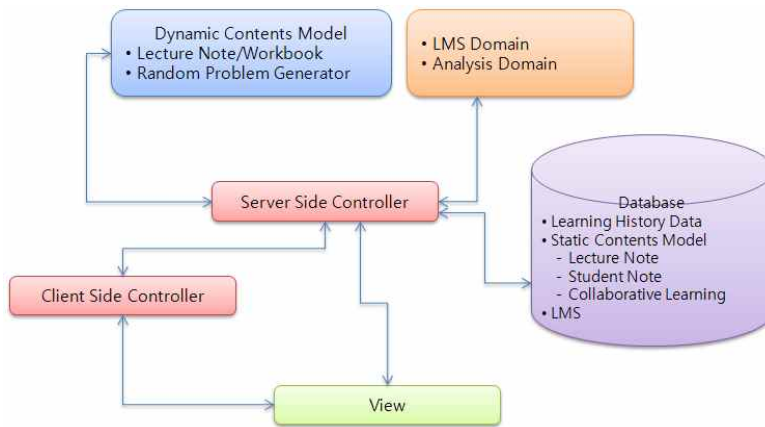
Figure 4.6: Framework for Implementing SmartNote

In order to provide dynamic contents, there is a corresponding model that is accessed by a server-side controller. The server-side controller delivers information related to appropriate view-generating for dynamic content model to the client-side controller. Then, the passed content model is rendered in a Dynamic HyperText Markup Language (DHTML) page and controlled by a client-side controller. The data resulting from learning activities is passed from the client-side controller to the server-side controller which then saves the data in the database by mapping the corresponding domain objects.

To see the summarized result for learning activities, the client-side

controller requests the work from the sever-side controller. The server-side controller receives the request maps to analyze the domain objects after retrieving the corresponding data from database. After this process, the analyzed results are passed to the client-side controller which then shows the results by rendering a DHTML page. The LMS and other related things are to be used in the same way.

4.4.2. Detailed Framework

The more detailed framework of SmartNote is shown in Figure 4.7.
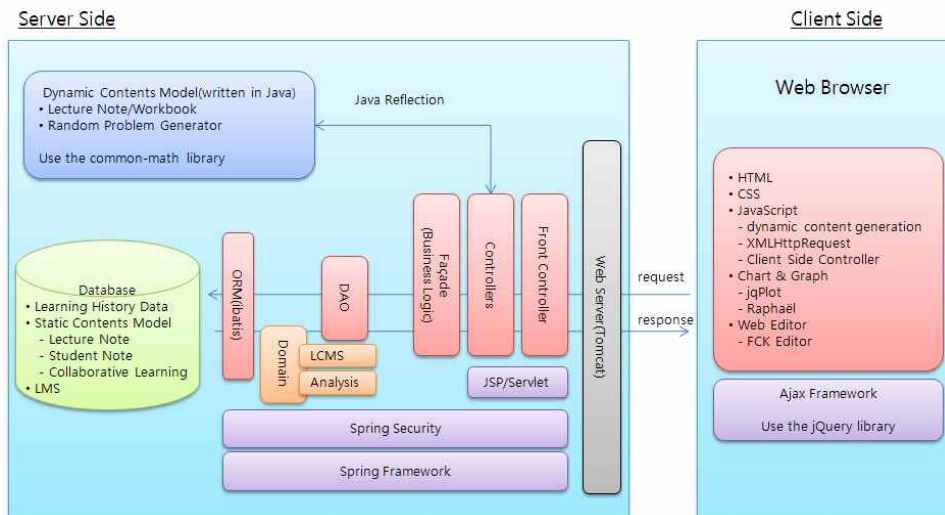

Figure 4.7: Detailed Framework of SmartNote

Spring Framework is used as the integration layer for the server-side framework of SmartNote while Ajax Framework is used as the integration layer for the client-side framework of SmartNote. Spring Framework is the most popular open source framework written in Java programming language, and provides various solutions for accessing the database and

generating the models and views. The dynamic content model is written in Java programming language. Java Reflection technique is used to communicate between the server-side controller and the dynamic content model. To provide the individualized contents, the dynamic content model uses random mechanisms with a seed value like student number. Therefore, students can request only their own learning contents. The request and response, between client and server, is handled via a Web server like Tomcat and the data occurred in this process is saved in a database.

End users are able to use the contents provided via a Web server and, since user requests are handled by using the Ajax communication protocol, the way enables the users to use the contents without moving pages resulting in more effective communication with the server. Furthermore, the users can concentrate on only their activities since the communication occurs in a way that only requests data to server without changing the user interface.
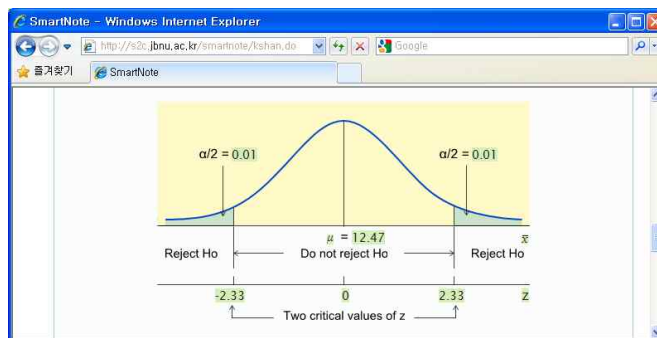

Figure 4.8: SmartNote's User Interface using Ajax

In the past, we mainly used graphic objects such as Java applets, Flash

Animations and Chart FX based on Active-X only when installing plug-ins. The problems with these chart or graphic objects are: First, plug-ins had to be installed for using these objects, and second, it takes a lot of time to load; since the objects work in plug-in, most of the communication with the server is very difficult.

With the advancements of hardware, loading time is no longer an issue but the difficulty of communication with the server is a big problem since learning activities are saved in a database. However, SmartNote resolves these problems by using the chart or graphic library based on Ajax. SmartNote uses Raphaël, one of the graphic libraries base on Ajax.

To create static contents on the Web, a Web Editor with features like word-processor is fundamental. SmartNote uses FCK Editor (Figure 4.9) as a Web Editor and adds a function writing mathematics expression. FCK Editor also inherits the benefits of Ajax since it was developed under Ajax-based.
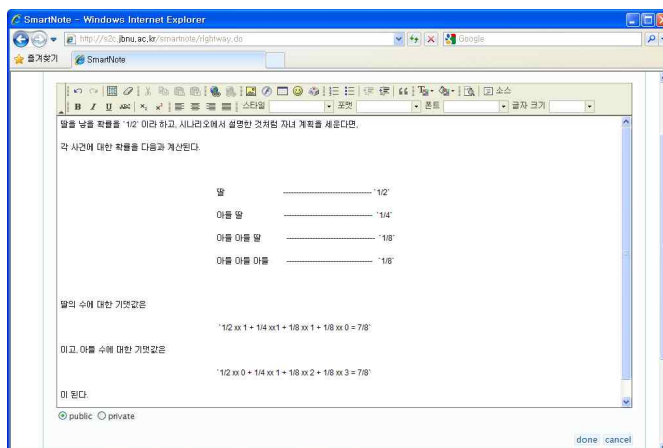
Figure 4.9: FCK Web Editor Used in SmartNote

4.5. Development Environment and Tools

Table 4.2 represents the development environment and tools used in developing SmartNote. The tools used are all open source software excepting the operating system and DBMS. Of course, it is not a problem to replace these with a free operating system and DBMS.

Table 4.2: Development Environment and Tools in SmartNote

Item	Development Tools
Operating System	Server: Microsoft Windows 2008 Server
	Client: Microsoft Windows XP, Vista
Web Server	Apache Tomcat 6
DBMS	Oracle 11g
Web Page	HTML
	JSP
	CSS
	Ajax
Dynamic Content Model	Java 6.0
Enterprise Java Framework	Spring Framework 3.0
Security	Spring Security 3.0
ORM	ibatis 2.3.4
Ajax Framework	jQuery 1.4, org.json
UI Framework	jQuery UI 1.8
	jQuery DataTable 1.7
Statistics Library	Apache Common-math 2.0
Math Expression	ASCIIMathML 2.0,
	MathPlayer 2.0
Chart & Graph	Raphaël 1.5.0
Web Editor	FCK Editor 2.6.3

4.6. User-Specific Feature and Feature of Module

One application is the subject of the action, which it is usually called an "actor" or "user" while a "role" is features that an actor is able to take on. Also, the target of actions taken by the actor is called a "module". The role is abstract since it is the defined as that in which an actor will be allowed to take some action. In comparison, module is more concrete than role since it is the real target in which an actor will take action and the authority is that according to the role. Section 4.6 begins with the definition of the role according to actors and then will address the available modules according to the role.

4.6.1. User-Specific Features

Most LMSs are developed according to the roles of users for personal identification and provide individualized pages. In the same manner, SmartNote was developed according to the roles of users. In SmartNote, there are three types of roles — administrator, teacher and student — considering the purposes of the teaching and learning environment. In addition to these roles, collaborative learning requires several roles to share the learning activities within each group.

1) Administrator

The authority of the administrator is minimized as the administrator is only able to register a new teacher. The authority to open a new course and manage the course and students is delegated to teachers. The

minimization of the administrator's authority is intended to maximize the empowerment of teachers.

2) Teacher

In reality, it is meaningless for any teacher to have authority in the course of another teacher. Therefore, SmartNote allows for teachers to only have authority of their own courses.

Before the start of each semester, teachers need to decide whether to use computers in the classroom and dynamic contents. After setting them to do so, they can select the menu and modules which will be shown or used in the course. Selected menus and modules are in the same context as the teaching methods that the teacher wants to apply. In addition, teachers can edit the table of contents shown in Figure 4.10 so that they can often organize the contents dynamically.
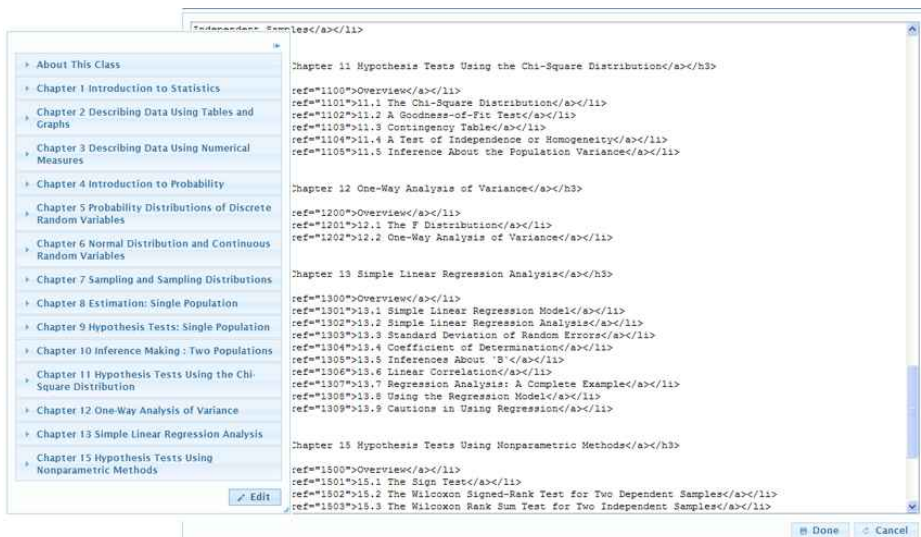

Figure 4.10: SmartNote's Table of Contents

Teachers are able to register and de-register students for courses. Also, they are able to manage the attendance of students after writing a time schedule for a semester. In reality, it's universal for teachers to check student attendance in the classroom but, in SmartNote, students should register their class attendance via computer before starting a lesson. In the event of computer failure or insufficient computers available in the class, the teacher can also check attendance. Teachers may frequently reorganize contents and manage the life cycle of the contents. Teachers manage the students' learning out of class so as not to neglect their learning and can take appropriate action for students who have obstacles to learning or do not concentrate in the classroom since understanding of the learning situation is happening in real time.

Teachers may use the module supporting group activity as well as individualized learning in class. It is possible to generate groups for the group activity. Figure 4.11 shows the screen that allows the teacher to automatically generate groups in class.
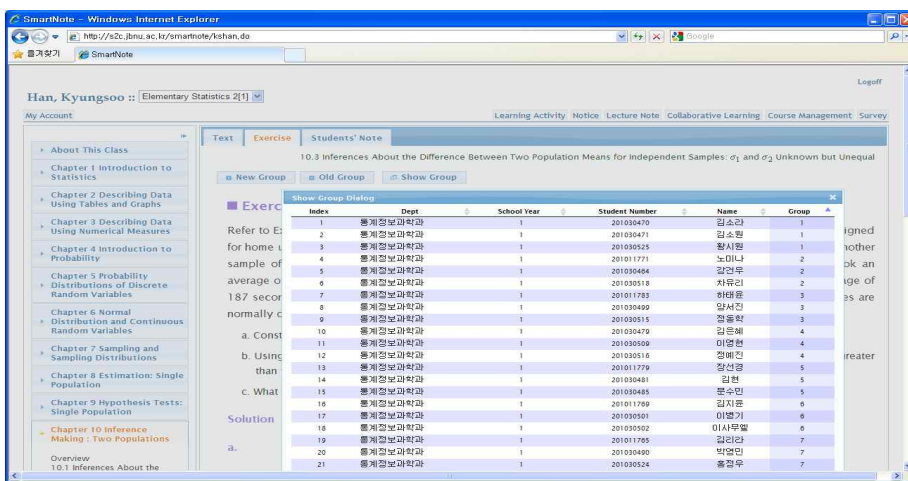

Figure 4.11: Teachers Can Automatically Generate Groups in Class

Large and complex problems not resolved in class time can be solved through collaborative learning to improve student's problem solving abilities. To do this, teachers have the authority to create problems for groups to solve. Also, teachers can frequently create assessment items for peer and group assessments as well as manage the project schedule. SmartNote allows teachers to see the journals of group activities, add comments to group activities and encourage the collaborative learning of each group to be improved by sharing the outcomes of group activities.

Teachers have the authority to offer static lecture notes to their students by writing notes. It is possible to distinguish between the students who write such and those who do not since the notes written by students can be aggregated and arranged. Also, SmartNote allows teachers to control whether or not to share the students' notes. It is helpful for students to modify their faults by themselves through comparing their notes with those of other students (see Figure 4.12).
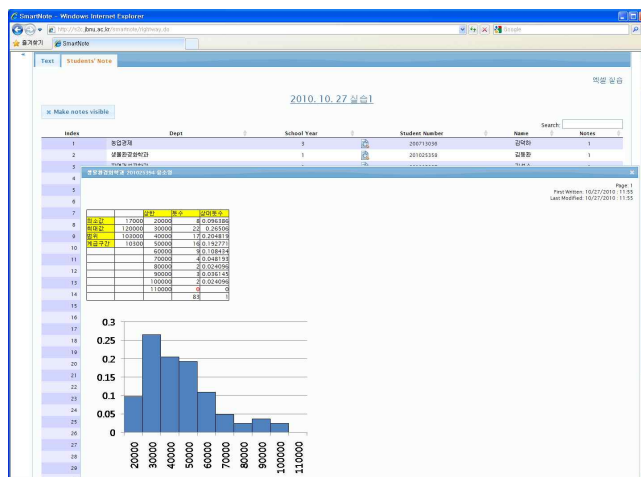
Figure 4.12: Comparison of Student Notes

Teachers can communicate with students by posting information relevant to the course, such as SmartNote tips or exam schedules, on the bulletin board. Authorities can be summarized as follows in accordance with the teacher's role:

- course management;
- class time schedule management;
- student management (enrollment, modification, attendance);
- menu and modules management;
- modifying personal information;
- contents management (contents life cycle management);
- assessment management;
- understanding the learning activities;
- notice management;
- writing the static lecture notes;
- examining and sharing the aggregated students note;
- presenting static or dynamic lecture notes; and
- collaborative learning management:
  - offering the project or problem;
  - generating the groups;
  - writing and management of group and peer assessment items;
  - checking the assessment results; and
  - group activity outcome management.

3) Student

In SmartNote, students have to perform the role as active producers of

knowledge as well as the role as passive consumers of knowledge by strengthening the authorities. Students perform learning activities using learning contents and they produce the LHD as a result. Of course, students do not know the process of generating the LHD. The LHD that students generate includes both quantitative data and qualitative data. The typical quantitative data is that which occurs in learning activities such as filling in short blanks, solving multiple choice questions and so on through students' workbooks. Qualitative data is that which occurs through more solving or writing notes. Students are able to see the results to learning activities in real time since the LHD produced during learning activities is automatically collected and analyzed. Therefore, students can easily and continuously monitor their learning.

Students must first check their attendance and can summarize important information on their notes. Also, they complete individualized activities and group activities through projects offered in the class.

Students have to complete a certain number of tasks to prepare and review within a set time period after school which makes students engage in class. Students also participate in collaborative learning with small groups for projects that require more time, and evaluate peers and other groups to help students whose learning is slow and to prevent students from riding on the work of their group members.

In collaborative learning, students allot each member a role and complete group activities according to these allotted roles. All group activities are shared within the group and the outcomes (Figure 4.13) of group activities are used as evidence to evaluate other groups.
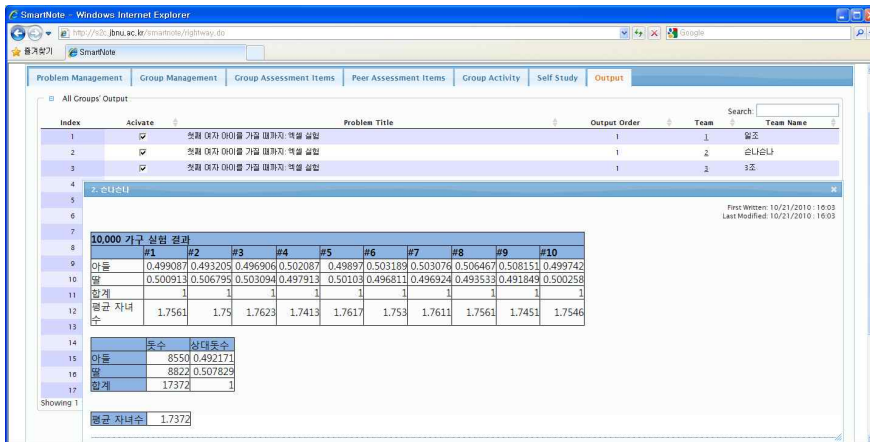
Figure 4.13: Outcomes of Student Group Activities

For the student's role, authorities can be summarized as follows:

- learning activity (as a producer of knowledge):
    - producing quantitative/qualitative LHD;
    - write and manage the individualized note; and
    - collaborative learning:
        - ✓ allotting roles within groups;
        - ✓ peer and group assessments;
        - ✓ writing the journal of group activity; and
        - ✓ writing the outcome of group activity.
- retrieving learning contents;
- seeing the results of learning activity;
- checking attendance;
- checking notice; and
- modifying personal information.

4.6.2. Modules Provided in SmartNote

Figure 4.14. provides an overview of modules available in SmartNote.

Figure 4.14: Overview of Modules Available in SmartNote

SmartNote consists of about 20 modules and can be divided into 6 basic modules:

- LMS/CLE;
- Selector & Navigator;
- Learning Contents;
- Learning Activity Monitor & Analysis Engine;
- Survey; and
- Notice Board.

1) LMS/CMS

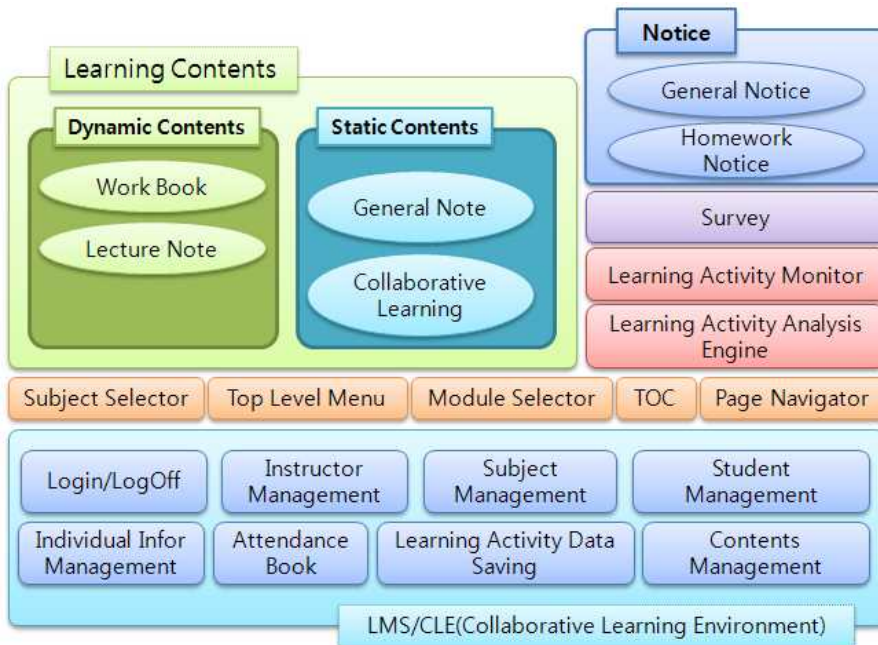As a module for user management, learning object management and LHD management are an infra of SmartNote. This module supports all modules. All teachers and students are able to monitor learning state and the history of learning activities via this module. For teachers, this module supports course management and student management while saving the history of learning activities of students.

2) Selector & Navigator

This module makes it possible for users to select the courses and content that they want to access. In addition to contents, it allows the user to retrieve the learning history by content. The menu structure of SmartNote is shown in Figure 4.15 and Figure 4.16. A user selects a subject and then selects the menu of high level. Next, the user selects the module that he/she wants to access. To retrieve contents, the user could use pages wanting the teaching or learning by using TOC and page navigator.

Figure 4.15: SmartNote Menu Structure 1
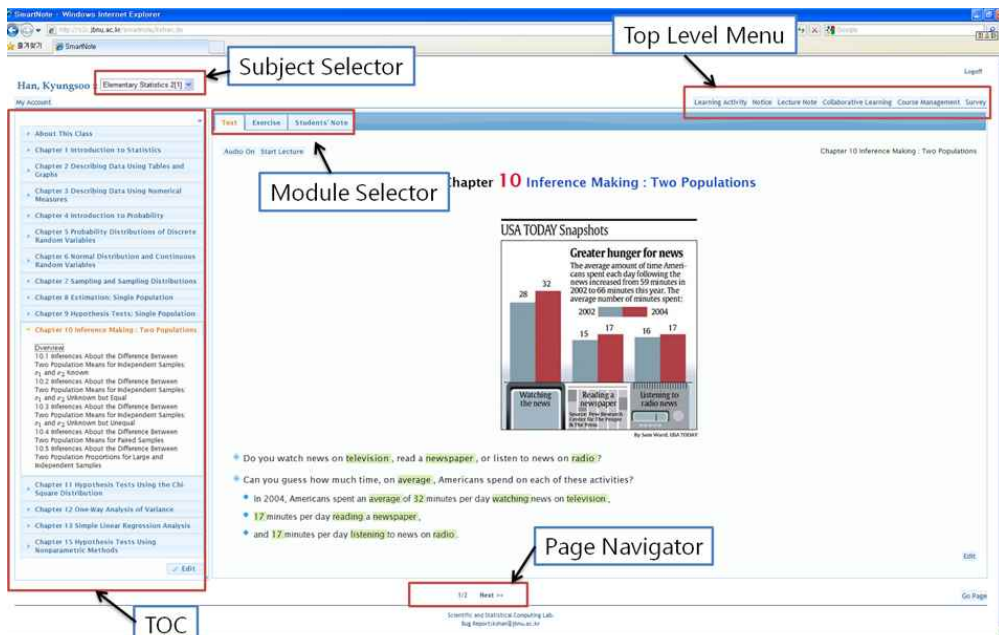
Figure 4.16: SmartNote Menu Structure 2

3) Learning Contents

Learning content is divided into dynamic content and static content. Dynamic content has to have a content model for each teacher (Lecture Note) and student (Workbook) as shown in Figure 4.17.

Students learn by using the Workbook and the results of learning activities are saved in the database via the LMS. Since a dynamic content model can be re-used once it has been written, other teachers could also use the dynamic contents in their statistics classrooms.
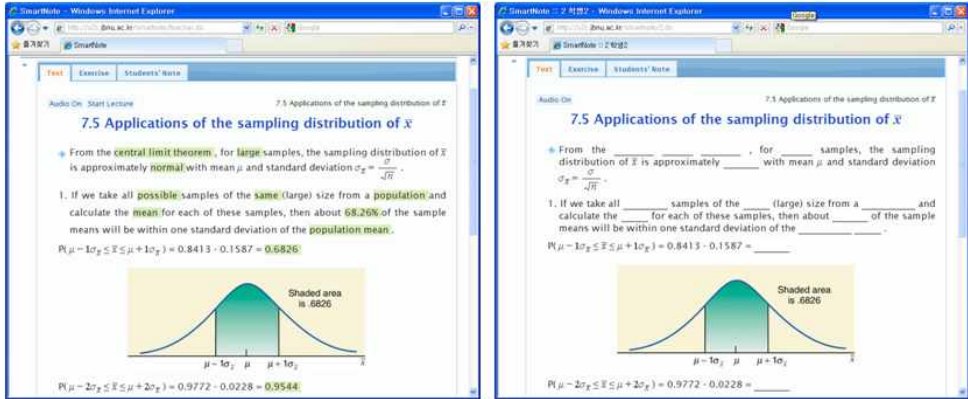
Figure 4.17: Content Model for Teachers and Students in Dynamic Content

The static contents are lecture note, student note and pages in the collaborative learning modules. The lecture notes of the teacher are visible on the students' note page which is useful since students can see the notes anytime and anywhere. Students can also summarize these to remember important information. The Lecture Note and Workbook generated by the dynamic content model will be compatible with static contents: lecture note and student note.

The pages in the collaborative learning module are for supporting the learning theories such as problem-based learning and collaborative learning.

4) Learning Activity Monitor & Analysis Engine

The LHD for learning activities is passed to the Analysis Engine via the LMS as depicted in Figure 4.18, and the analyzed result is then passed to the Learning Activity Monitor for teachers and students.
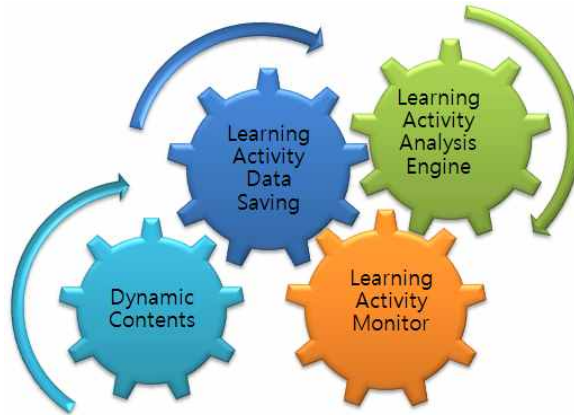
Figure 4.18: Learning Activities' LHD Passes to the Analysis Engine via the LMS

Figure 4.19: Exemplar Results Requested by the Teacher in Monitoring Student Activity

SmartNote currently provides summarized statistics such as current learning activity, learning time, learning score or performance. Figure 4.19 is the response result of when a teacher requests information as to how many hours students have studied by using conditions such as section, date, contents type and so on.

5) Survey

SmartNote provides a survey module to investigate matters such as student satisfaction and utilization of the course. The survey data collected in real time is automatically analyzed and its analyzed results are shared with both teachers and students. The Survey module can also be used to understand students' comprehension in class and is arguably more effective since students are more likely to respond with silence to the teacher's questions during class. It is, practically, difficult to hold Question and Answer (Q&A) sessions with many students. However, this problem will be resolved if the teacher uses the Survey module.

The Survey module can also be used as a data collection tool. The collected data is downloadable in an Excel file and it is a suitable file format that most statistical softwares commonly use. This is meaningful in the sense that teachers and students are able to use real data inexpensively and quickly in their classrooms.

The Survey model requires question types in order for the data collected through the survey to be easily used in the analysis. Question types are nominal, ordinal, numeric and open-ended. Figure 4.20 shows the screen of the question form. Since SmartNote uses FCK Editor to create a questionnaire, it is possible to embed multimedia such as images, animations and Java applets.
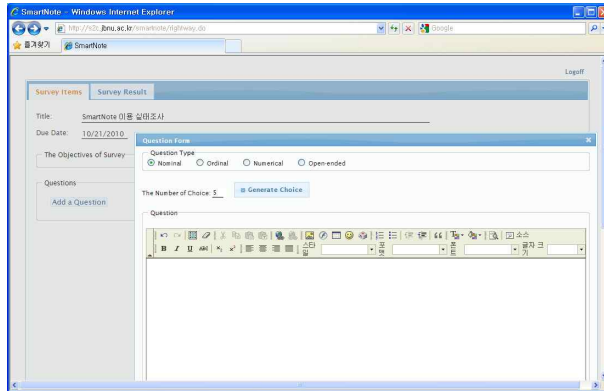
Figure 4.20: Question Form in the Survey
Module of SmartNote

6) Notice Board

The teacher can use the General Notice Board to make general announcements to students. This Notice Board supports interaction between the teacher and students. Also, the teacher can notify students of homework, its range and the due date via the Homework Notice Board (Figure 4.21) enabling students to learn after school based on these notices.
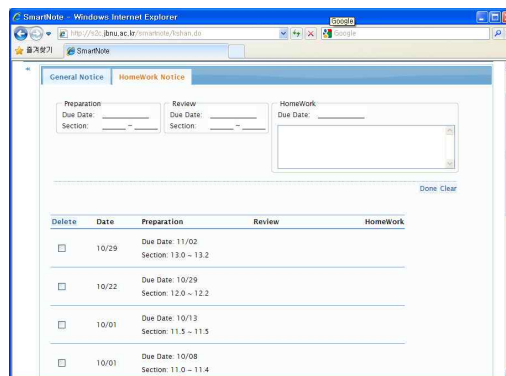
Figure 4.21: Homework Notice Board
in SmartNote

5. Application of SmartNote and Its Results

SmartNote, the integrated teaching and learning environment developed by this study, has been applied in classrooms since the first semester of 2010. It has an application to manage students' learning out of class by developing dynamic contents, and to experiment with learning theories, which are suggested in order to change students' attitudes towards statistics and to improve students' learning in several areas, such as hands-on experiment, simulation and collaborative learning. Through these applications, it is possible to understand that students have misconceptions about the statistical concepts resulting in a negative attitude towards statistics. Chapter Five introduces the application of SmartNote and discusses its results.

5.1. Application of SmartNote

5.1.1. One Daughter Policy

The "One Daughter Policy" activity was composed in order to assess whether or not students had learned the concept of probability and were able to build a probability model for a real problem based on their learned knowledge. The task required students to recompose China's "One Son Policy" for decreasing the population to fit the current situation of the South Korea.

The class, *Practical Use of Computer*, is a major for the freshmen in the Department of Statistics at Chonbuk National University. The contents of

learning are mainly basic computer skills and how software such as Microsoft Excel can help with learning statistics. The class size is 24 and most students learned the concept of probability in the first semester course, *Elementary Statistics Ⅰ*. Therefore, they are appropriate subjects to assess whether or not their probabilistic thinking has been formed.

Table 5.1 summarizes carefully planned sequences of activities and the modules of SmartNote for the experiment:

Table 5.1: One Daughter Policy Activity

Learning Activity	Used SmartNote Module
presenting scenario	Survey/Collaborative Learning
the first diagnosis of pre-knowledge	Survey
providing forms with Excel to aggregate the results of experiments	Lecture Note
aggregating and sharing the results of choosing paper and a tossing coin	Collaborative Learning's Output
the second diagnosis of knowledge	Survey
aggregating and sharing the results of Excel simulation	Collaborative Learning's Output
the final diagnosis of knowledge	Survey
providing the probability model	Lecture Note

To increase the students' interest, a newspaper article related to the preference for female offspring was also provided. This explained that most newly-weds will want to have at least one daughter since the preference for female offspring will increase in society 10 years from now when students reach an appropriate marriageable age in 2020. This means that these couples will continue to have children until they have a daughter. However, most plan to stop after the third child since the burden is

child-rearing is so great. The following scenario was presented to students:

1. If the first child is a girl, they do not have any more children.
2. If the first child is a boy, they have a second or even a third child in case of the second child is also a boy.
3. The maximum number of children allowed is three.

In groups of three or more, students had to decide whether or not the maternity policy presented in the scenario would change the sex ratio at birth; each group gave their thoughts and reasons. Only two of the seven groups decided that the ratio would not change. Three groups answered that the number of sons would be higher than the number of daughters, and the remaining two groups disagreed. When looking at their reasons, one team attempted to calculate the probability considering the number of cases while other teams had misconceptions that maternity policy would change the sex ratio at birth (Figure 5.1).
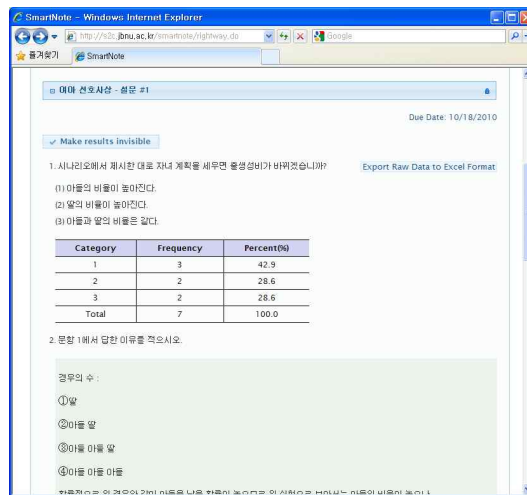
Figure 5.1: Misconception in Probability

Each team did a hands-on experiment before doing a computer simulation. Two slips of paper in the same size were provided to each team: "Son" was written on one slip and "Daughter" on the other. First, they randomly chose one of the two slips of paper provided as stated in the scenario, and recorded the outcomes in the Excel file provided before the experiment. Also, they experimented by tossing a coin. If the outcome was heads, they recorded a son in the Excel file otherwise they recorded a daughter. In the Output of Collaborative Learning module, they summarized the outcomes of both experiments (random selection and a coin toss) for five households. These results were then shared.

After finishing the hands-on experiment, each team responded to the same question: Whether or not the maternity policy presented in the scenario would change the sex ratio at birth. Three groups responded that the ratio would not change. Three groups answered that the proportion of daughters would be greater than the proportion of sons and the remaining one group responded in contrast. These responses were very similar to the experiment results of each group. Through this experiment, it was possible to understand that students tend to have blind faith in their experiment results without really interpreting them.

Using Excel, students then carried out computer simulations to answer the following question: Are we able to decide the sex ratio at birth using a 10 times experiment? To perform this simulation, an Excel file was provided to each team beforehand. Each team repeated the experiment 10 times for 10,000 households and recorded the outcomes of 10 times in the Output of Collaborative Learning module. The final survey was to

understand that the misconception in probability is changed. Consequently, five teams answered that the ratio would not be changed. However, two teams answered that the proportion of daughters would be greater than the proportion of sons and they still had a misconception in the probability. Table 5.2 represents the results of the 3 times survey.

Table 5.2: Modification of Misconception in Probability

Item	Prior Knowledge	Hands-on Experiment	Computer Simulation
1. the proportion of sons will be higher	3	1	0
2. the proportion of daughters will be higher	2	3	2
3. the proportion of sons and daughters will same	2	3	5
Total	7	7	7

Many students were immature in interpreting the simulation results, and experienced difficulty in using a probability model in the process of drawing conclusions. Finally, the learning activity was finished with the explanation in which, using the probability model, the expectation values of sons and daughters are the same; therefore the maternity policy presented in the scenario cannot change the sex ratio at birth.

A finding of this experiment is that even though students learned the concept of probability, students's misconceptions are resilient and quite difficult to change. Also, teaching methods such as hands-on experiment and computer simulation are effective in making students engage in the classroom; however, such teaching methods are insufficient to dispel the misconception of probability. Therefore, teachers need to make additional

efforts to dispel students' misconceptions.

The "One Daughter Police" experiment took three hours to complete. It is believed to have taken more time since students learned simulation methods using Excel while carrying out the experiment. However, it is possible to do such experiments because SmartNote allows for the collecting and sharing of results of experiments. SmartNote is useful for understanding students' misconceptions.

5.1.2. Simulation Activity for Central Limit Theorem

A simulation activity for the Sampling Distribution of sample mean and Central Limit Theorem (CLT) was carried out in similar manner to the activity of Section 5.1.1. Participants were students enrolled in the course *Information Collection and Analysis*, and the class size was 38. The classroom was composed of the students of 15 departments and most students had mathematics anxiety so teaching statistics was not easy. In particular, students had a difficulty with statistical concepts such as the sampling distribution of sample mean and CLT.

To help their conceptual understanding of CLT, the activity required students to bring 10 coins to the lesson. Overall, 34 of the 38 students used the Survey module to input the year in which each coin was minted, and the data of 340 coins was collected. They estimated the mean of the data and calculated the mean of the minting years of the 10 coins that each student had brought to the lesson. Then the students estimated the distribution of the data and create a histogram to identify the distribution. Next, the students randomly sampled 10 of the 340 coins and calculated

the mean of the sampled data. This process was repeated many times and student created a histogram about sample means. In the same way, students increased the sample size and created histograms of sample means according to each sample size. Through computer simulation using Excel, students could recognize that the distribution of the sample mean is approximately Normal Distribution as the sample size increases (Figure 5.2). Figure 5.2 represents that students are immature to use statistical terminology despite being able to create the histogram of the sample mean.

Page: 1
First Written: 11/01/2010 : 15:50
Last Modified: 11/01/2010 : 15:50

무차별 추출시 동전의 연도

■연도

최대값	2004.2
최소값	1993.8
표준편차	2.513757
범위	10.4

상한	도수	상대도수
1994	1	0.02
1996	3	0.06
1998	12	0.24
2000	10	0.2
2002	15	0.3
2004	8	0.16
2006	1	0.02
2008	0	0
2010	0	0
합계	50	1
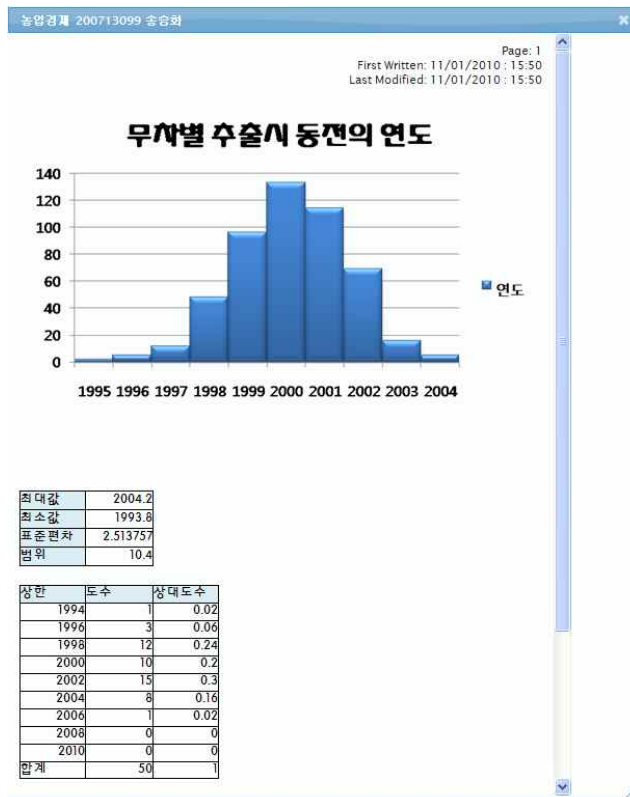
Figure 5.2: Simulation to Central Limit Theorem Using Excel

The activity also asked the following questions to grasp the students' understanding of CLT:

1. When tossing a dice, what is the outcome?

2. When tossing a dice 10,000 times, what is the distribution of outcomes?

3. When tossing two dice 10,000 times at the same time, what is the distribution of the sum of each outcome?

4. When tossing five dice 10,000 times at the same time, what is the distribution of the sum of each outcome?

5. What is the reason for each question?

Figure 5.3 is an example for questions 2, 3 and 4.
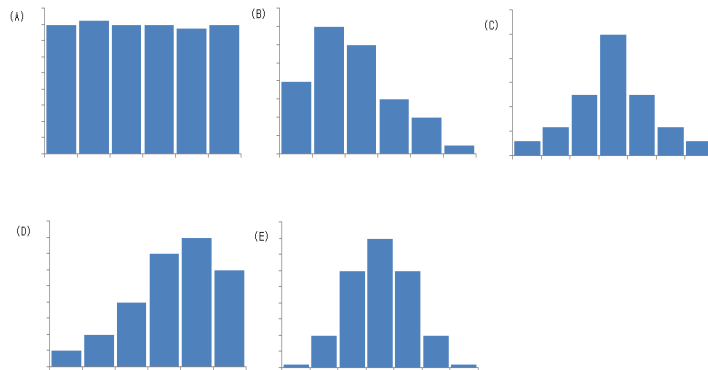
Figure 5.3: Examples for Question2, 3 and 4

Table 5.3 is the percentage of correct answers for each question.

Table 5.3: Student Understanding of the CLT

Question	Correct Answer(%)
1	26(83.9)
2	28(90.3)
3	17(54.8)
4	13(41.9)
Total	31(100)

The first and second questions ask for a basic knowledge of probability. 10% to 16% of students had no knowledge at all of probability. The third and fourth questions ask for students' understanding of the CLT. The overall results for these questions show that approximately 50% of students understood the CLT. In particular, the percentage of correct answers for the fourth question was relatively low. When looking into this, the reason students gave for the percentage of correct answers for the fourth question being lower than that of the third question was that students can calculate the probability for each random variable (from 2 to 12) easily in the third question while students gave up trying to calculate the probability for each random variable in the fourth question because of wide range of random variables (from 5 to 30). That is, the result for the questions revealed many students did not understand the CLT.

SmartNote helped students understand the CLT by embedding the Java applet of West and Ogden (1998) in SmartNote since the simulation activity using Excel was insufficient to improve the students' understanding (see Figure 5.4).
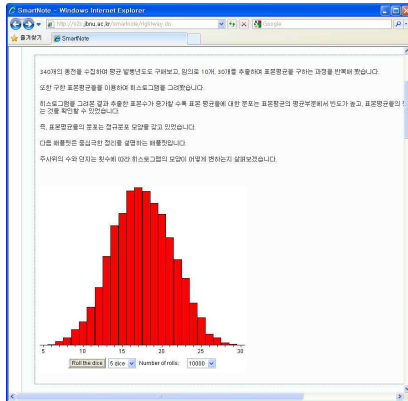
Figure 5.4: CLT Simulation Applet by West & Ogden

The activity was designed to enable students to use the applet for their learning. Their computing environment, however, could not support the Java Virtual Machine (JVM) so they can only see the results of simulation using the Java applet shown on the beam projector of the teacher's computer.

After explaining the CLT further, using the Java applet, students were asked additional questions to determine their understanding of the CLT. The questions and results are as follows:

1. Is the Java applet helpful in understanding the CLT?

Table 5.4: Utility of Java Applet

Category	Frequency	Percent(%)
1) Very helpful	9	29.0
2) Somewhat helpful	15	48.4
3) So so	6	19.4
4) Not helpful	1	3.2
5) Not at all helpful	0	0.0
Total	31	100.0

2. Are Excel and Java applet helpful simulation tools in understanding the CLT?

Table 5.5: Preference between Simulation Tools － Excel and Java Applet

Category	Frequency	Percent(%)
1) Excel	6	19.4
2) Java applet	11	35.5
3) Both were helpful	13	41.9
4) Both were not helpful	1	3.2
Total	31	100.0

3. Do you think that the distribution of sample mean will follow Normal Distribution if the sample size is large enough even though a population is not symmetric at all?

Table 5.6: Confirmation Question to Central Limit Theorem

Category	Frequency	Percent(%)
1) Yes	20	64.5
2) No	3	9.7
3) I don't know	8	25.8
Total	31	100.0

Many students responded that the Java applet and Excel simulation were helpful in understanding the CLT. Also, the response results showed that such tools are somewhat useful in improving the students' understanding. However, despite a clear explanation of the statistical concept by the teacher, it is difficult for all students to master the CLT.

5.1.3. Lecture Note and Workbook

SmartNote is an environment that is able to support dynamic contents. It has also been revised to support the dynamic content to put its philosophy into practice. However, this study will not introduce the dynamic content in detail because it is out of the subject related to this study. The dynamic contents model was developed by another teacher who has now been using his contents for two semesters for the course, *Elementary Statistics*. Dynamic contents consist of two types: Lecture Note for teachers and Workbook for students.

Figures 5.5 and 5.6 show the contents for teachers and students respectively. Teachers can use Lecture Note in the classroom and students can perform the learning outside of class anywhere and anytime.
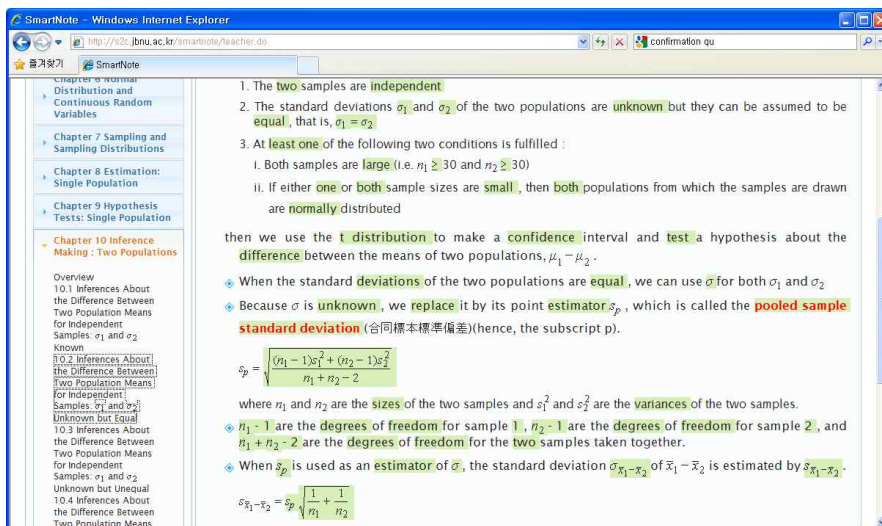
Figure 5.5: Lecture Note for Teacher
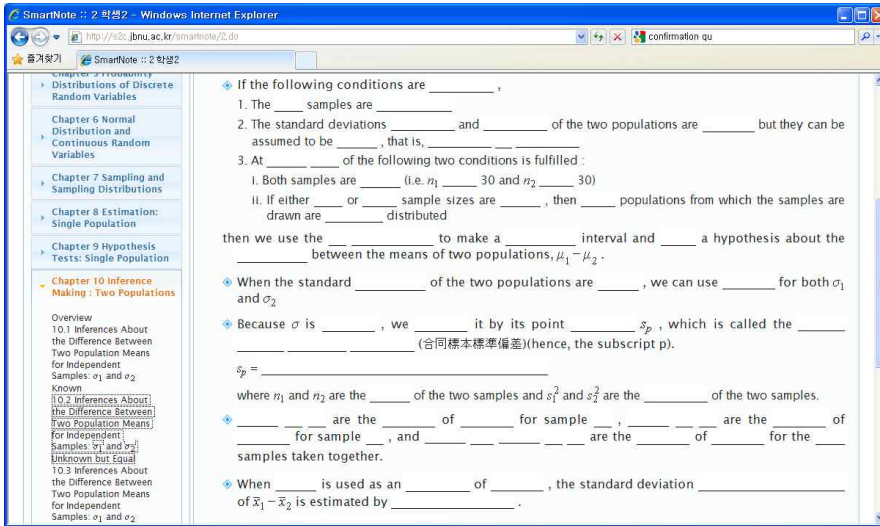
Figure 5.6: Student Workbook

5.2. Results of Analysis to Learning History Data

This study analyzed the data related to students' notes summarizing their practice in the *Information Collection and Analysis* course, and the data related to Workbook usage in the *Elementary Statistics* course. The participation during computer lab time in the *Information Collection and Analysis* course involved 333 observations and 84,764 LHDs for "Chapter 11 Hypothesis Tests Using the Chi-Square Distribution" in the *Elementary Statistics* course were used to determine the learning time and learning performance of the class. In addition, 331,792 LHDs were used to determine the number of students and weekly learning time in the *Elementary Statistics* course. The information in the data sets used to analyze is shown in Table 5.7.

Table 5.7: Data Sets to Analyze Learning History Data

	Course	N	Extra Info.
Participation	Information Collection and Analysis	333	08/23/2010 ~ 10/31/2010
learning time and performance of out of class	Elementary Statistics	84,764	(Chapter 11) 09/26/2010 ~ 10/31/2010
the number of students and learning time of out of class	Elementary Statistics	331,792	08/23/2010 ~ 10/31/2010

1) Attendance and Participation

The class, *Information Collection and Analysis*, emphasizes problem -solving skills in real world context through computer lab activities such as data collection, data handling, data analyzing, computer simulation and so on. The learning by doing approach has several benefits to enhance students' abilities to comprehend complex subjects as previously noted in Section 2.2. However, managing and monitoring the activities is quite difficult so students' computer lab activities normally have been excluded from formative assessments. Eventually, the majority of students has overlooked the computer lab activities and engaged in other activities (such as talking with peers, web surfing and internet chatting) because the activities are not include in the formative assessments. To encourage participation in the computer lab activities, the students had to record their activities and their outcomes in computer lab with SmartNote.

During computer lab activities, the students competitively asked lots of questions about their learning and were involved in the activities with

enthusiasm. Table 5.8 and Figure 5.7 represent the descriptive statistics used to find participation in the computer lab activities. The results show that participation is very high with a median of 95.7%.

Table 5.8: Descriptive Statistics of Attendance and Participation

N(Class Size) = 38

	MIN	MEDIAN	MAX
Attendance	78.9%	92.1%	100.0%
Participation	82.4%	95.7%	100.0%
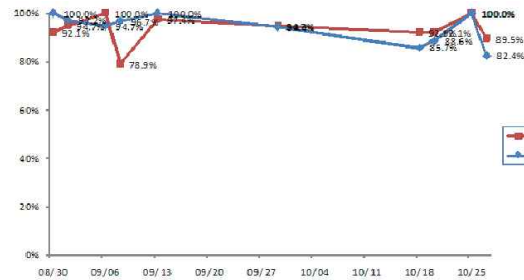
Figure 5.7: Attendance and Participation

Although informative, the minority of students actively took part in the computer lab activities when SmartNote was not used in earlier courses from 2008 to 2009. At that time, Blog was adopted for the courses and was insufficient to enable students to be involved in the computer lab activities. The students complained using the Blog in the classroom since it is difficult to find the location to put the outcomes of their activities. However, the students of this semester appreciated SmartNote because they could easily find the locations and see the other students' works. Therefore, SmartNote contributes to enhance the course.

2) Learning Time and Performance

In the past, leading students to learn outside the classroom hardly is possible. Moreover tracking the students' learning outside of the classroom nearly is impossible. Since managing and monitoring the learning are quite difficult and time intensive, most teachers are not concerned with the students' learning outside of the classroom. Consequently, the majority of students neglects studying and is always being ill-prepared for his or her classes. According to a Kyosu newspaper article (July 10, 2006), the weekly learning time of college students for their major is less than 3 hours. This shows severe lack in learning.

To facilitate the learning outside of the classrooms, SmartNote provides dynamic learning contents for the students in the *Elementary Statistics* course. Table 5.9 and Figure 5.8 are the results showing the analyzed learning time versus performance in using the dynamic contents by performing K-Means Clustering and Descriptive Statistics. As the results show, students were divided into three groups and it was found that groups have distinct tendencies. Group Ⅰ is a very dedicated group with learning performance at 95.3% and learning time at 5.6 hours while the students in Group Ⅲ did almost no study and the group shows the opposite learning behavior to that of Group Ⅰ. Group Ⅱ consists of 18% of the total students and this group's learning performance is around 50%.

Remarkably, Group I, which had the most dedicated learning performance, consisted of 71% of the total students. This means that the number of students who work hard is 6.5 times greater than those who

don't. Also, it is remarkable that the overall learning performance is 76.7% and that students studied Chapter 11 for 4.5 hours. Therefore, SmartNote contributed significantly in encouraging and facilitating student learning.

Table 5.9: Learning Time and Performance of each Group

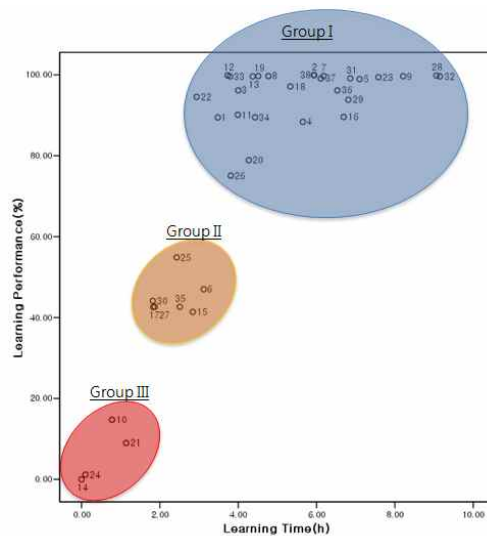|	Group Ⅰ	Group Ⅱ	Group Ⅲ	Total
Learning Time(h)	5.6±0.3	2.3±0.2	0.5±0.3	4.5±0.4
Learning Performance(%)	95.3±1.3	45.0±1.8	6.2±3.5	76.7±5.2
N(%)	27(71.0)	7(18.0)	4(11.0)	38(100.0)

Figure 5.8: Clustering Using Learning Time and Learning Performs

3) Number of Students and Their Learning Time by Day of Week

Many students delay their learning until the deadline on homework assignments or exam dates. Ordinary, they do not study hard and attempt

overnight studying before the deadline dates. These learning styles may interrupt the successful learning process and may cause learning defects. Therefore, it is important to change the learning style because it is a key point for students not to lose the interest in their learning.

To determine whether the dynamic contents provided in SmartNote change the students' learning style or not, this study analysed LHDs generated in the *Elementary Statistics* course by the day of week. The number of students and their learning time is summarized in Table 5.10 using descriptive statistics by the day of week. Figures 5.9 and 5.10 are box-plots to compare the number of students and their learning time by the day of week. The results show that 12 students (31%) learn everyday using SmartNote. It is remarkable that several students study so hard, even over weekends, although there is difference according to the days. The class times for the course are Wednesdays (1 hour) and Fridays (2 hours). Considering these class times, it is meaningful that students also spent time learning on Sundays, Mondays and Saturdays. Students worked more than 45 minutes per day except Thursdays where they worked for approximately 1 hour.

Table 5.10: Descriptive Statistics of Out-of-class Learning

Day	N	Number of Students			Learning Time(Minute)		
		M	S.D	S.E	M	S.D	S.E
Sun	10	7.7	5.21	1.65	43.0	30.88	9.76
Mon	10	8.3	6.45	2.04	46.3	22.36	7.07
Tue	10	16.3	11.01	3.48	41.2	20.22	6.40
Wed	10	15.1	10.20	3.23	44.4	26.82	8.48
Thu	10	19.4	13.70	4.33	59.9	37.98	12.01
Fri	10	11.0	6.34	2.01	39.2	16.49	5.21
Sat	10	5.0	3.37	1.06	39.4	27.75	8.78
Total	70	11.8	9.67	1.16	44.8	26.56	3.17
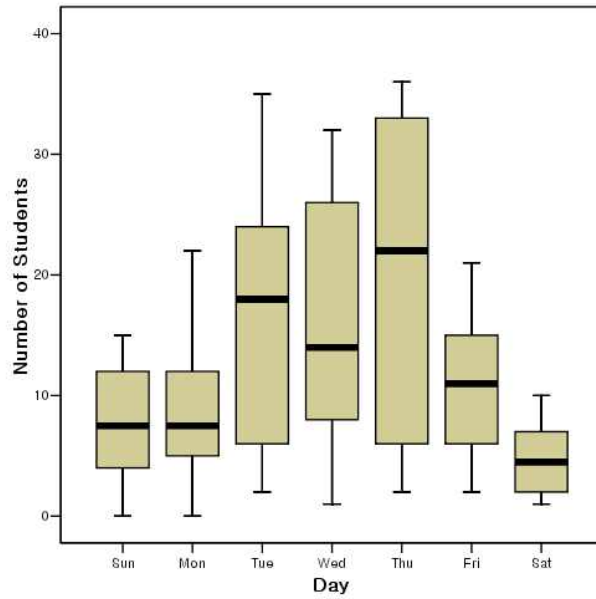
Figure 5.9: Number of Students Who Studied Out of Class
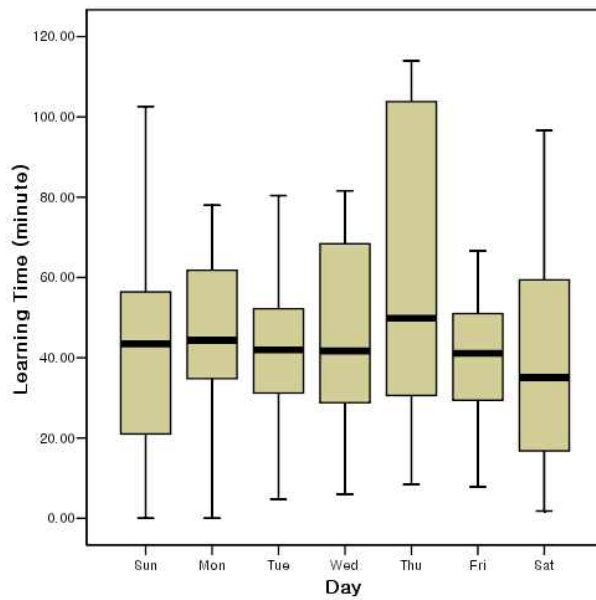
Figure 5.10: Learning Time of Out-of-Class

5.3. Survey Results on the Effective Use of SmartNote

A survey was conducted to investigate the efficacy of using SmartNote from October 8, 2010 to October 13, 2010 with regard to: 1) students' concentration in the classroom; 2) average preparation time per week; 3) the degree of self-performed assignments; and 4) attitudes towards learning statistics. Overall, 35 of the 38 students in the *Elementary Statistics* course responded and the survey method was a web survey provided by SmartNote.

1) Concentration in Class

Professor Han, the teacher of the *Elementary Statistics* classroom, suffered as a result of the majority of his students not concentrating in class. He used to complain that even students sitting in front seats make a noise and talk with peers not at all related to learning. In fact, this experience is not unique to him alone and many statistics teachers have commonly experienced it. In order to enhance concentration in the class, he teaches statistics using dynamic contents provided in SmartNote. He reports that students now concentrate in the classroom more than before.

To identify students' concentration, a question was presented to the students. Students' responses to the question are shown in Table 5.11. No students responded that they concentrate more than 90% in the classroom; however, the results showed that many students concentrate more in the *Elementary Statistics* classroom, which uses SmartNote, than in the

Calculus classroom which does not use SmartNote.

Table 5.11: Concentration in Classroom

Category	Elementary Statistics		Calculus	
	Frequency	Percent(%)	Frequency	Percent(%)
More than 90%	0	0.0	0	0.0
About 70%	16	45.7	7	20.0
About 50%	17	48.6	11	31.4
About 30%	0	0.0	10	28.6
Less than 10%	2	5.7	7	20
Total	35	100.0	35	100.0
Missing	3		3	

2) Average Preparation Time per Week

Clearly, Statistics is not a subject in which students can achieve their learning goals with only class work. To develop the ability to use statistical concepts and methods, students have to devote considerable time and effort through a steady and continuous exposure via lecture, readings, activities and problems — lots of problems. In this context, it is very important to prepare the lesson beforehand because an ill-prepared student is reluctant to be attentive to the class work. However, most students are unwilling to prepare to their class work and go to the classroom without having prepared any readings.

To identify the amount of preparation needed is nearly impossible and is quite difficult because the history to preparation could not be documented. As a result, most teachers overlook the preparation though they emphasize its importance to their students. The key feature to manage and analyze the preparation history was considered as an

important factor to improve students' learning since SmartNote has been developed.

A question was presented to the students to investigate student preparation time per week and its response results including comparison with the *Calculus* class summarized in Table 5.12. The survey results show that, overall, 68.7% of students spend more than 3 hours per week preparing for the statistics lesson. When compared to the average of 45 minutes of learning time that students had previously indicated (Table 5.10), this result shows many students focus on preparation rather than review. In contrast, the majority of students (80%) spend almost no hours per week preparing for the mathematics lesson. These dramatic findings show that SmartNote contributes significantly to increasing the number of hours students spend preparing for the statistics lesson.

Table 5.12: Time of Preparation a Week

Category	Elementary Statistics		Calculus	
	Frequency	Percent(%)	Frequency	Percent(%)
More than 4 hours	8	22.9	0	0.0
About 3 hours	16	45.7	1	2.9
About 2 hours	5	14.3	6	17.1
About 1 hours	5	14.3	9	25.7
Not at all	1	2.9	19	54.3
Total	35	100.0	35	100.0
Missing	3		3	

3) Self-Performed Assignment

The use of so-called 'drill and practice' exercises is almost universal in elementary statistics courses. Such exercises are particularly attractive for

teachers to set as homework assignments since they tend to have unique numerical answers, making them much quicker to mark that more open-ended tasks where students engage in discussion of their results. Regrettably, the exercises are equally attractive to a minority of lazy students who can happily copy the solutions of a more diligent but weak-willed colleague (Hunt, 2005).

The purpose of this investigation is to discover how to help combat the plagiarism of homework assignments when SmartNote is used in the *Elementary Statistics* course. Table 5.13 shows that the overall proportions of assignments for statistics and mathematics on their own are significantly different. A large portion (54.2%) responded that they complete more than 70% of the statistics assignments on their own while only a very small portion (8.6%) does not. In contrast, only a small group (22.9%) completes more than 70% of the mathematics assignments on their own while a very large number (42.8%) of lower performing students does not.

Table 5.13:   Self Performed Assignment

Category	Elementary Statistics		Calculus	
	Frequency	Percent(%)	Frequency	Percent(%)
More than 90%	6	17.1	3	8.6
About 70%	13	37.1	5	14.3
About 50%	13	37.1	12	34.3
About 30%	2	5.7	9	25.7
Less than 10%	1	2.9	6	17.1
Total	35	100.0	35	100.0
Missing	3		3	

Students are copying the mathematics homework of other students in groups during the break time before the lesson. It is possible to copy the homework because the same homework is offered to all students. SmartNote can successfully combat plagiarism of assignments because it is able to provide individualized homework assignments of the same content and level for the entire class.

4) Attitude Towards Learning Statistics

Finally, the survey investigated whether or not SmartNote changed students' attitudes towards statistics. Many researchers report that most students have several mental-blocks such as statistical anxieties or negative feelings towards learning statistics and they note that to change this is quite difficult. This study anticipates that SmartNote could change the attitudes; however, the results in Table 5.14 show that most students (77.2%) still recognizes that statistics is quite difficult. Therefore, it seems that a greater effort needs to be made to successfully change students' attitudes towards statistics.

Table 5.14: Attitude towards Learning Statistics

Category	Elementary Statistics		Calculus	
	Frequency	Percent(%)	Frequency	Percent(%)
Very Difficult	8	22.9	17	48.6
Difficult	19	54.3	13	37.1
So-so	8	22.9	5	14.3
Easy	0	0.0	0	0.0
Very Easy	0	0.0	0	0.0
Total	35	100.0	35	100.0
Missing	3		3	

Although these results may be depressing, when comparing the *Elementary Statistics* course and *Calculus* course, many students recognize that mathematics is more difficult than statistics.

6. Summary and Conclusions

6.1. Summary of the Dissertation

This study developed an integrated teaching and learning environment, SmartNote, providing a bridge between research findings and teaching practice in statistics education. Also, it attempted to examine the learning effects of teaching and learning methods and argued that they could improve statistics education by applying SmartNote in several classrooms. In order to develop SmartNote, this study conducted the following procedures:

(1) This study reviewed the literature related to statistics education to support pedagogies and learning theories to suggest their learning effectiveness in Smartnote. Suggested pedagogies and learning theories are as follows:

- Student-centered learning based on constructivism;
- Hands-on experiment;
- Active learning;
- Learning using technology like computer simulation; and
- Collaborative learning.

(2) A number of studies have emphasized the importance of using technology appropriately in statistics education. However, those studies

have only focused on the purpose of improving students' understanding and use restrictive technologies. This study considered using technology to grasp students' understanding as well as to improve students' understanding. However, there has been no study to meet these objectives in statistics educational research. Therefore, this study expanded its range to include general educational research. To efficiently manage learning, most colleges have LMSs. LMSs automatically store LHDs that students perform during their learning. Necessarily, to automatically analyze the LHDs became interesting issues and challenges for relevant researchers. However, LHD, a key element to track and manage learning process, was not pedagogical data format.

(3) Therefore, this study sought the collection method and practical use of LHD. This study concluded that LMSs should be able to interact with content organically, and SmartNote should be able to provide such an environment in order for LHD to meet the purpose of teaching and learning.

(4) As the pre-development phase for SmarNote, this study examined the design philosophy and features of Moodle, a representative LMS, and summarized features that SmartNote should include and new features that should be added. The determined features that SmartNote should provide are as follows:

- Course management;
- Uploading and sharing materials;
- Gathering, reviewing, and sharing assignments;

- Learning History Data Collection/Analysis;

- Collaborative Learning;

- Attendance Book; and

- Survey & Data Collector.

(5) This study built the design model and design principles for SmartNote and developed it using recent advanced computing technology.

(6) Finally, to show the usefulness of SmartNote, this study applied SmartNote in several classrooms and analyzed the collected LHD and survey data. No comparative experiment was carried out in this study to claim the learning effectiveness. This study agrees with Mills (2002) that an evaluation may be difficult, as ethical issues may arise in the selection, which students taught according to the different methods.

6.2. Conclusions and Further Research

The results of this study are significant for several reasons. SmartNote enables teachers to easily implement several teaching and learning methods in the classroom which is difficult to practice in the existing classroom environment. Students said that the use of SmartNote and the teaching methods are fresh and innovative with one voice. In particular, SmartNote is an useful teaching and learning environment to encourage students' participation and facilitate students' learning. However, this study found that it is difficult to dispell students' misconception for particular statistics conception and to develop statistical thinking through using SmartNote.

SmartNote needs to be updated so that learning activities will be able to be managed more systematically than the current version. LHD collection and analysis also needs to be elaborated upon to investigate students' learning behaviors more closely. SmartNote provides a collaborative learning environment for students; however, it does not support teachers' collaboration. It needs to consider an environment in which various pedagoies and learning contents can be shared among teachers. Such an environment will be helpful in seeking an effective classroom model. Finally, further studies to develop statistical thinking should be conducted. If these studies are integrated into SmartNote, it will result in an integrated teaching and learning environment for all teachers and students.

Bibliography

[1] Aguilera, M. A., Aguilera-Morillo, M. C., Ocaña, F. A., and Valderrama, M. J. (2010). Development of Online Material for Virtual Teaching/Leaning of a Course on Functional Data Analysis with "MOODLE", ICOTS8, July, 2010.

[2] Ahn, J.Y., Han, K.S., and Han, B.S. (2005). Web-based education: characteristics, problems, and some solutions, Int. J. Innovation and Learning, 274-282.

[3] Basturk, R. (2005). The Effectiveness of Computer-Assisted Instruction in Teaching Introductory Statistics, Educational Technology & Society, 8(2), 170-178.

[4] Ben-Zvi, D. (2007). Using Wiki to Promote Collaborative Learning in Statistics Education, *Technology Innovations in Statistics Education,* 1(1), Article 4.

[5] Beyth-Marom, R., Fidler, F., and Cumming, G. (2008). Statistical Cognition: Towards Evidence-Based Practice in Statistics and Statistics Education, *Statistics Education Research Journal*, 7(2), 20-39.

[6] Brandl, K. (2005). Are you ready to "MOODLE"?, *Language Learning & Technology*, 9(2), 16-23.

[7] Bremer, D. and Bryant, R. (2005). A Comparison of two learning management Systems: Moodle vs Blackboard, *Proceedings of the 18th Annual Conference of the National Advisory Committee on Computing Qualifications*. 135-139.

[8] Brescia, W. M. and Mille, M. (2006). What's it Wroth? The Perceived Benefits of Instructional Blogging, *Electronic Journal for the Integration of Technology in Education*, 5, 44-52.

[9] Brooks, G. and Raffle, H. (2005). FISH: A New Computer Program for Friendly Introductory Statistics Help, *Teaching Statistics*, 27(3), 81-88.

[10] Chance, B., Ben-Zvi, D., Garfield, J., and Medina, E. (2007). The Role of Technology in Improving Student Learning of Statistics, Technology Innovations in Statistics Education, 1(1), Article 2.

[11] Chu, A., Cui, J. and Dinov, I. (2009). SOCR Analyses: Implementation and Demonstration of a New Graphical Statistics Education Toolkit, Journal of Statistical Software, 30(3), 1-19.

[12] Cobb, G.W. and Moore D.S.(1997). Mathematics, Statics, and Teaching, The American Mathematical Monthly, 104(9), 801-823.

[13] Cole, J. and Foster, H. (2008). Using Moodle, 2nd edition. O'Reilly.

[14] Cornelius-White, J. (2007). Learner-Centered Teacher-Student Relationships Are Effective: A Meta-Analysis, Review of Educational Research, 77(1), 113-143.

[15] Cox, D.R. (1998). Some remarks on statistical education, *The Statistician*, 47, 211-213.

[16] Delialiogla, O. and Yildirim, Z. (2007). Students' Perceptions on Effective Dimensions of Interactive Learning in a Blended Learning Environment, *Education Technology & Society*, 10(2), 133-146.

[17] Dinov, I. (2006). SOCR: Statistics Online Computational Resource, *Journal of Statistical Software*, 16(11), 1-16.

[18] Dinov, I., Sanchez J, and Christou, N. (2008a). Central Limit Theorem: New SOCR Applet and Demonstration Activity, *Journal of Statistics Education*, 16(2).

[19] Dinov, I., Sanchez J, and Christou, N. (2008b). Pedagogical Utilization and Assessment of the Statistic Online Computational Resource in Introductory Probability and Statistics Courses. *Journal of Computers & Education*, 50, 284-300.

[20] Dinov, I. and Christou, N. (2009). Statistics Online Computational Resource for Education. *Teaching Statistics*, 31(2), 49-51.

[21] Dinov, I., Christou, N., and Gould, R. (2009). Law of Large Numbers: the Theory, Applications and Technology-based Education, *Journal of Statistical Education* 17(1), 1-15.

[22] Dryver, A. (2009). The Enhancement of Teaching Materials of Applied Statistics Courses by Combining Random Number Generation and Portable Document Format Files via LATEX, *Journal of Statistical Software*, 31, Code Snippet 3.

[23] Ellis, R. K. (2009). A Field Guide to Learning management System, *Learning Circuits*.

[24] Everson, M., Ziefflet, A. and Garfield, J. (2008). Implementing New Reform Guidelines in Teaching Introductory Statistics Courses, *Teaching Statistics*, 30(3), 66-70.

[25] Gal, I., Ginsburg, L., and Schau, C. (1997). Monitoring Attitudes and Beliefs in Statistics Education. In I. Gal and J.B. Garfield (Eds.), *The Assessment Challenge in Statistics Education*, IOS.

[26] Garcia, E., Romero, C., Ventura, S. and, Calders, T. (2007). Drawbacks and Solutions of Applying Association Rule Mining in Learning Management Systems, *Proceedings of the International Workshop on Applying Data Mining in e-Learning 2007*.

[27] Garfield, J. (1995). How Students Learn Statistics, *International Statistical Review*, 63(1), 25-34.

[28] Garfield, J. and Ben-Zvi, D. (2007). How Students Learn Statistics Revisited: A Current Review of Research on Teaching and Learning Statistics, *International Statistical Review*, 75(3), 372-396.

[29] Garfield, J. and Ben-Zvi, D. Developing Students' Statistical Reasoning, *Springer*, 2008.

[30] Garfield, J. and Gal, I. (1999). Assessment and Statistics Education: Current Challenges and Directions, *International Statistical Review*, 67(1), 1-12.

[31] Garfield, J. and Chance, B. (2000). Assessment in Statistics Education: Issues and Challenges, *Mathematical Thinking and Learning,* 2, 99-125.

[32] Gnanadesikan, M., Scheaffer, R. L., Watkins, A. E., and Witmer, J. A. (1997). An Activity-Based Statistics Course, *Journal of Statistics Education*, 5(2).

[33] Grün, B. and Zeileis, A. (2009). Automatic Generation of Exams in R. *Journal of Statistical Software*, 29(10), 1-14.

[34] Hagtvedt, R., Jones, G.T., and Jones, K. (2007). Pedagogical Simulation of Sampling Distribution and the Central Limit Theorem, *Teaching Statistics*, 29(3), 94-97.

[35] Hagtvedt, R., Jones, G.T., and Jones, K. (2008). Teaching Confidence Intervals Using Simulation, *Teaching Statistics*, 30(2), 53-56.

[36] Han, B.S. and Han, K.S. (2005). Design and Implementation of Teaching Simple Random Sampling by Using Constructivism and Information Technology, *The Korean Communications in Statistics*, 12(1), 229-240.

[37] Han, K.S, Mun, G.S and Ahn, J.Y. (2009). Comparing the Use of Self and Peer Assessment: A Case Study in a Statistics Course, *Communications of the Korean Statistical Society*, 16(6), 979-987.

[38] Härdle, W., Klinke, S., and Ziegenhagen, U. (2006). e-Learning Statistics - A Selective Review. *In: Rizzi A, Vichi M, editors. 17th Symposium on Computational Statistics (COMSTAT 2006).* Rome, Italy; 2006. p. 417-428.

[39] Härdle, W., Klinke, S., and Ziegenhagen, U. (2007). On the utility of E-learning in statistics. *International Statistics Review*, 75(3), 355-364.

[40] Hunt, N. (2005). Using Microsoft Office to Generate Individualized Task for Students, *Teaching Statistics*, 27(2), 45-48.

[41] Hunt, N. (2007a). Individualized Statistics Coursework Using Spreadsheets, *Teaching Statistics*, 29(2), 38-43.

[42] Hunt, N. (2007b). Setting Personalized Homework Exercises Using ISCUS, *Teaching Statistics*, 29(3), 66-70.

[43] Hunt, N. and Tyrrell, S. (2000). Learning Statistics on the Web - DISCUSS, *Teaching Statistics*, 22(3), 85-90.

[44] Lee, K.K, Mun, G.S., and Ahn, J.Y. (2008). A Note on the Use of Peer Assessment to Improve Pupil's Performance, *Journal of Korean Data & Information Science Society*, 19(2), 443-450.

[45] Larreamendy, J., Leinhardt, G., and Corredor, J. (2005). Six Online Statistics Courses: Examination and Review, *The American Statistician*, 59(3), 240-251.

[46] Luehmann, A.L. and Frink, J. (2009). How Can Blogging Help Teachers Realize the Goals of Reform-based Science Instruction? A Study of Nine Classroom Blogs, *Journal of Science Education and Technology*, 18, 275-290.

[47] Lunsford, M. L., Rowell, G.H., and Goodson-Espy, T. (2006). Classroom Research: Assessment of Student Understanding of Sampling Distributions of Means and the Central Limit Theorem in Post-Calculus Probability and Statistics Classes, *Journal of Statistics Education*, 14(3).

[48] Machado, M., Tao, E. (2007). Blackboard vs. Moodle: Comparing User Experience of Learning Management Systems, I*n: 37th annual Frontiers in education conference - global engineering: knowledge without borders, opportunities without passports (FIE 2007)*, S4J 7-12.

[49] Matsui, T. and Okamoto, T. (2003). Knowledge Discovery from Learning History Data and its Effective Use for Learning Process Assessment under the e-learning Environment, *Society for Information Technology and Teacher Education International Conference(SITE) 2003*.

[50] Meyers, S. A., Bender, J., Hill, E. K., and Thomas, S. Y. (2006). How Do Faculty Experience and Respond to Classroom Conflict?, *International Journal of Teaching and Learning in Higher Education*, 180-187.

[51] Mittag, H.J. (2002). Java Applets and Multimedia Catalogue for Statistics Education, *ICOTS6*.

[52] Mills, J.D. (2002). Using Computer Simulation Methods to Teach Statistics: A Review of the Literature, *Journal of Statistics Education,* 10(1).

[53] Moore, D.S. (1997). New Pedagogy and New Content: The Case of Statistics, *International Statistical Review*, 123-165.

[54] Muehlenbrock, M. (2005). Automatic Action Analysis in an Interactive Learning Environment, *Proceedings of the workshop on Usage Analsysis in Learning System at AIED-2005*.

[55] Mun, K.S., Han, B.S., Han, K.S., Ahn, J.Y. (2007). Development of a Dynamic Geometry Environment to Collect Learning History Data, *Journal of Korean Data & Information Science Society*, 375-384.

[56] Mvududu, N. (2005). Constructivism in the Statistics Classroom: From Theory to Practice, *Teaching Statistics*, 27(2), 49-54.

[57] Nolan, D. and Temple Lang, D. (2007). Dynamic, interactive documents for teaching statistical practice, *International Statistical Review*, 75(3), 295-321.

[58] Pfaff, T.J. and Weinberg, A. (2009). Do Hands-On Activities Increase Student Understanding?: A Case Study, *Journal of Statistics Education*, 17(3).

[59] Ransdell, S. (1997). Teaching Applications of the World-Wide Web, *Behavior Research Methods, Instruments & Computer*, 29(2), 217-221.

[60] Rijpkema, K., Boon, M., Berkum, M.E., and Bucchianico, A.D. (2010). STATLAB: Learning DOE by Doing!, *ICOTS8*.

[61] Romero, C., Ventura, S., and Garcia, E. (2008). Data Mining in Course Management Systems: Moodle Case Study and Tutorial. *Computers and Education*, 51(1), 368-384.

[62] Roseth, C.J., Garfield, J.B., and Ben-Zvi, D. (2008). Collaboration in Learning and Teaching Statistics, *Journal of Statistics Education*, 16(1).

[63] Schuyten, G., & Thas, O. (2007). Statistical Thinking in Computer-based Learning Environments, *International Statistical Review*, 75(3), 365-371.

[64] Schwarz, C.J. (1997). StatVillage: An On-Line, WWW-Accessible, Hypothetical City Based on Real Data for Use in an Introductory Class in Survey Sampling, *Journal of Statistics Education*, 5(2).

[65] Shutes, K. (2009). A Note on Using Individualised Data Sets for Statistics Coursework, *Technology Innovations in Statistics Education*, 3(2).

[66] Snee, R.D. (1993). What's Missing in Statistical Education?, *The American Statistician*, 47, 149-154.

[67] Sorcinelli, M.D. (1994). Dealing with Troublesome Behaviors in the Classroom, *In K.W. Prichart & R.M. Sawyer (Eds). Handbook of college teaching: Theory and applications*, 365-373.

[68] Strauss, H. (2005). Why Many Faculty Members Aren't Excited about Technology, *Distance Education Report*, 9(13), 1-8.

[69] Symanzik, J. and Vukasinovic, N. (2003). Comparative Review of ActivStat, CyberStats, and MM*Stat, *MSOR Connections*, 3(1), 37-42.

[70] Symanzik, J. and Vukasinovic, N. (2003). Teaching Experiences with a Course on "Web-Based Statistics", *The American Statistician*, 57(1), 46-50.

[71] Symanzik, J. and Vukasinovic, N. (2006). Teaching an Introductory Statistics Course with CyberStats, an Electronic Textbook, *Journal of Statistics Education*, 14(1).

[72] Ueno, M. (2005). Animated Pedagogical Agent based on Decision Tree for e-Learning, *Proceedings of the Fifth IEEE International Conference on Advanced Learning Technologies(ICALT'05)*.

[73] Velleman, P.F. (2000), Design Principles for Technology-Based Statistics Education, *Metrika*, 51, 91-104.

[74] Velleman, P.F. and Moore, D.S. (1996). Multimedia for Teaching Statistics: Promises and Pitfalls, *The American Statistician*, 50(3), 217-225.

[75] Watson, J. and Donne, J. (2009). TinkerPlots as a Research Tool to Explore Student Understanding, *Technology Innovations in Statistics Education*, 3(1), Article 1.

[76] West, W. and Ogden, R.T. (1998). Interactive demonstrations for statistics education on the World Wide Web, *Journal of Statistics Education*, 6(3).

[77] West. W. (2009). Social Data Analysis with StatCrunch: Potential Benefits to Statistics Education, *Technology Innovations in Statistics Education*, 3(1), Article 2.

[78] Xie, P., Ye, L., Huang, Y., Chen, Y. and, Lin, L. (2010). Research on the Method of Recomposing Learning Objects and Tools in Adaptive Learning Platform, *Edutainment 2010, LNCS 6249*, 326-336.

[79] Zieffler, A., Garfield, G., Alt, A., Dupuis, A., Holleque, K., and Chang, B. (2008). What Does Research Suggest About the Teaching and Learning of Introductory Statistics at the College Level? A Review of the Literature, *Journal of Statistics Education*, 16(2).

URL References

[80] ATutor, http://atutor.ca/

[81] Consortium for the Advancement of Undergraduate Statistics Education(CAUSE), http://www.causeweb.org

[82] EduTools, http://www.edutools.info

[83] Guidelines for Assessment and Instruction in Statistics Education(GAISE), http://www.amstat.org/education/gaise/

[84] HyperStat, http://davidmlane.com/hyperstat/

[85] International Association for Statistical Education(IASE),
http://www.stat.auckland.ac.nz/~iase/

[86] Kyosu Newspaper (2006),
http://www.kyosu.net/news/articleView.html?idxno=10044

[87] O'Reilly, T. (2005). What Is Web 2.0: Design Patterns and Business Models for the Next Generation of Software, http://www.oreilly.com/lpt/a/6228

[88] Sakai, http://sakaiproject.org/

[89] Saville, B.K. (2009). Using Evidence-Based Teaching Methods to Improve Education, https://tle.wisc.edu/solutions/increasing-student-success/using-evidence-based-teaching-methods-improve-education

[90] Seeing Statistics, http://www.seeingstatistics.com/

[91] WebCT, http://www.webct.com

[92] Zacker's blog(Higher-ed LMS market penetration), http://www.zacker.org/higher-ed-lms-market-penetration-moodle-vs-blackboard-vs-sakai