AN INVESTIGATION OF FACTORS RELATED TO PRESERVICE SECONDARY MATHEMATICS TEACHERS' COMPUTER ENVIRONMENT PREFERENCES FOR TEACHING HIGH SCHOOL GEOMETRY

DISSEPTION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Heréndira García-de Galindo, B.S., M.S.

The Ohio State University
1994

Dissertation Committee: Approved by

Sigrid Wagner
Douglas T. Owens
Suzanne K. Damarin

Adviser
College of Education
TO MY PARENTS

AND

TO MY HUSBAND

WHOM I LOVE AND DEEPLY ADMIRE
ACKNOWLEDGMENTS

Thank God For The Spring

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\(^1\) Consejo Nacional de Ciencia y Tecnología de México [National Council of Science and Technology of Mexico].
Maiden Name: ... Heréndira García Tello

September 1976 to June 1981 ....... B.S., National University
    Autonomous of Mexico, Mexico City
September 1982 to January 1984 .... M.S., Center of Research and
    Advance Studies, Mexico City
September 1983 to December 1988 ... Lecturer and Researcher.
    Division of Mathematics Education. Center of Research and
    Advanced Studies of the National Polytechnic Institute. México City.
    MEXICO.

September 1982 to June 1983 ....... Mathematics Teacher (Grades 8
    to 9). Escuela Hermanos Revueltas. [Private School]. México City. MEXICO.

April 1981 to September 1983 ........ Lecturer. Division of
    Mathematics Education. Center of Research and
    Advanced Studies of the National Polytechnic Institute. México City.
    MEXICO.

December 1981 to September 1982 ... Consultant: Elementary
    Mathematics (Grades K to 5). "Primary School by
    Television." Ministry of Public Education. México City.
    MEXICO.

September 1980 to June 1981 ....... Mathematics Teacher (Grades 7
    MEXICO.
PUBLICATIONS


FIELDS OF STUDY

Major Field: Education

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CHAPTER I

COMPUTERS IN TEACHER EDUCATION

It is hard to think about computers of the future without projecting onto them the properties and the limitations of those we think we know today. And nowhere is this more true than imagining how computers can enter the world of education. (Papert, 1980, p. 5).

We live in the Information Age and "there are obvious, but urgent, needs to prepare all people to function adequately in the technological society in which they will have to live and work" (Panel on Science and Mathematics Education, 1985, p. 15). However, schools and teachers are not yet ready to satisfy this social demand (Becker, 1990; Cohen, 1988; Malcom, 1988; Panel of Science and Mathematics Education, 1985; Plomp, and van de Wolde, 1985). Although several models of computer uses in mathematics education have been developed (Solomon, 1986; Taylor, 1980), schools have not adapted education to be taught with the aid of computers. On the one hand, schools have acquired computers and educational software but the instruction process remains unchanged (Becker, 1990; Office of Technology Assessment, 1988). On the other hand, prospective teachers are
not getting the experience they need to teach with the aid of computers and they are highly apprehensive toward computers (Liu, Ree, and Phillips, 1990).

The purpose of the present study was, initially, to observe whether there was a difference between observed patterns of teaching strategies and evaluation procedures in regular classes, that is, classes without the aid of computers, and the preferred teaching strategies and evaluation procedures of preservice secondary mathematics teachers when planning to teach high school geometry with the Geometric Supposer and/or the Geometer's Sketchpad. However, the study included the exploration of teaching styles, classroom interactions, and computer uses. This chapter contains the following three sections: (a) the problem of interest, (b) the rationale, and (c) the significance of the study.

The Problem

New technologies are creating new types of jobs or modifying traditional roles in current occupations. To define new roles for teachers in computer environments, it is necessary to explore how computers will modify current ways of teaching and, conversely, how current teachers' preferred teaching styles will determine the use of computers in educational settings (Olson, 1988). Computers have had a great impact in many areas of human production—business, communications, medicine, and many
others—so it was natural to think that computers would revolutionize schools and would help to enhance achievement. However, as was mentioned above, most elements of the instructional process remain the same, though schools have acquired computers and educational software. Part of the problem may be that teacher education students are not getting enough computer experience.

According to Cornu (1992), considerable progress has been made in the development of computer hardware and software, and many valuable educational experiments have been carried out during the last ten years; however, computers are still not commonly used. Cornu has observed that in many schools computers are locked in a special room, and it is not easy for teachers to use them. Teachers must plan in advance, be sure the room is available, get the key and check and prepare the computers. Then pupils come to the computer room, and generally what is done in the time spent there is not totally related to what is taught in the classroom.

There is a gap between the actual use of computers in schools and the potential use of computers in education described by pioneers like Alfred Bork, Thomas Dwyer, Arthur Luehrmann, Seymour Papert, and Patrick Suppes (Taylor, 1980). This investigator has explored factors that determine the teacher's selection and use of geometry software trying to understand the
source of the differences of educational computer uses between teachers and computer programmers and educational planners. Chapter 2 includes a characterization of computer programmers and schoolteachers. Prior to the present study, two pilot studies were carried out to explore school teacher's attitudes toward different types of geometry software. The main facts observed during these pilot studies, which led to the present study, are listed in what follows.

Garcia-Tello, Kent, and Blake (1992) explored whether the use of computers in teaching high school geometry favored boys more than girls. These authors report no gender differences when teaching geometry with the aid of computers. (This pilot study allowed observation of how the teachers who participated in the study selected and used geometry software.) In terms of software selection, teachers preferred a drill-and-practice type of software when they were to select a geometry software from among the following three: Geometric Supposer (Schwartz, and Yerushalmy, 1985a, 1986a, 1987a), Geometer's Sketchpad (Jackiw, 1991)a, and Geometry Concepts (Geometry Concepts, 1987). In terms of uses of software, the two high school teachers transferred the method of teaching used in the regular classroom into the computer laboratory, that is, asked students to work individually, to follow directions, and do activities similar to those in a regular geometry class. They did not teach new concepts when using the computers
but, rather, reviewed basic concepts, that is, definitions of geometrical shapes (different types of triangles and quadrilaterals, and the circle lines, that is, radius, diameter, tangent, chord, and secant) and geometrical relationships like parallel and perpendicular lines, and the angles of a circle; they also included some activities to help students memorize the formulas to calculate the area of these geometrical shapes. They asked students who finished before the others to wait for the whole class before starting a new activity.

The second pilot study included the demonstration of three kinds of geometry software—Geometric Supposer, Geometer’s Sketchpad, and NonEuclid. The first two software packages were designed to teach high school geometry while the last one was designed to study hyperbolic geometry (Austin, Castellanos, D’Arnell, and Estrada, 1992). This pilot study was carried out in three sessions of two hours each. The first hour of the first two sessions was devoted to activities with the Geometric Supposer: Triangles (Schwartz and Yerushalmy, 1985a) the first day, and Quadrilaterals (Schwartz and Yerushalmy, 1986a) the second day. Teachers explored NonEuclid only for one hour, the first hour of the third day. The second hour of the three sessions was devoted to activities with the Geometer’s Sketchpad. In this occasion, the geometry activities for the Geometric Supposers and the Geometer’s Sketchpad were taken mainly from the manuals
(Schwartz, J., and Yerushalmy, M. 1985b; Schwartz, J., and Yerushalmy, M., 1986b; and Jackiw, N., Bennet, D., Klotz, E., Schattschneider, D., Schmalzried, C., and Hale, J., 1991b). The author of these notes wrote a list of ten activities to explore some geometrical relationships in hyperbolic geometry using NonEuclid. A Likert type scale to measure the attitude of participating teachers toward the geometry software was given after the demonstration of each software.

García-Tello (1994) reports the results of the second pilot study, that is, the geometry software evaluation by 13 mathematics teachers. All teachers had previous experience in programming. All teachers were graduate students in mathematics education. All teachers had taken geometry classes. Not all teachers had taught geometry at the high school level. The sample included elementary (n = 1), high school (n = 8), and college (n = 4) teachers. Three Likert type scales were given to measure teachers' attitudes toward the use of geometry software to teach high school geometry. Almost all teachers who did not have experience teaching geometry at high school level marked "undecided" and this affected the results. (It would be interesting to observe teachers' evaluation of the software after they actually tried to use them to teach their geometry classes.) The means for each of the four items of the scales given to evaluate the potential teaching effectiveness of the
Geometric Supposer, the Geometer's Sketchpad, and the NonEuclid are given in what follows.

**Geometric Supposer.** Data show that teachers tend to agree that the Geometric Supposer makes an appropriate use of graphs, that students would like to work with this software and that the Geometric Supposer will help students to make conjectures in geometry. Item 3 of the Likert type scale illustrates that participating teachers would like to teach geometry with this software (See Figure 1).

<table>
<thead>
<tr>
<th>Geometric Supposer</th>
<th>SD</th>
<th>D</th>
<th>U</th>
<th>A</th>
<th>SA</th>
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</thead>
<tbody>
<tr>
<td>1. The software makes an appropriate use of the graphs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(3.72)</td>
</tr>
<tr>
<td>2. High school students will like to work with this software.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(4.00)</td>
</tr>
<tr>
<td>3. I would like to try this software with my own students.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(4.00)</td>
</tr>
<tr>
<td>4. This software will help students to make conjectures about geometric relationships.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(4.18)</td>
</tr>
</tbody>
</table>

**Figure 1.** Attitude Toward the Use of the Geometric Supposer to Teach High School Geometry
**Geometer's Sketchpad.** Figure 2 shows that participating teachers tend to agree that the Geometer's Sketchpad makes an appropriate use of the graphic capabilities of the computer. However, data show that participating teachers do not agree that students will like this software, and that they would not use the Geometer's Sketchpad to teach Euclidean geometry to high school students.

<table>
<thead>
<tr>
<th>Geometer's Sketchpad</th>
<th>SD</th>
<th>D</th>
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<th>SA</th>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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</table>

Mean

1. The software makes an appropriate use of the graphs. (3.20)

2. High school students will like to work with this software. (2.50)

3. I would like to try this software with my own students. (2.50)

4. This software will help students to make conjectures about geometric relationships. (3.10)

**Figure 2.** *Attitude Toward the Use of the Geometer's Sketchpad to Teach High School Geometry*

**NonEuclid.** Figure 3 shows that teachers tend to agree that high school students would like to work with NonEuclid and they would like to try this software with their students. Figures 2 and 3
show that participating teachers tend to have a more positive attitude toward the software NonEuclid than the Geometer's Sketchpad.

<table>
<thead>
<tr>
<th>NonEuclid</th>
<th>SD</th>
<th>D</th>
<th>U</th>
<th>A</th>
<th>SA</th>
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<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

1. The software makes an appropriate use of the graphs. (3.84)  
2. High school students will like to work with this software. (4.07)  
3. I would like to try this software with my own students. (4.15)  
4. This software will help students to make conjectures about geometric relationships. (4.07)  

**Figure 3.** Attitude Toward the Use of the NonEuclid to Teach High School Geometry

Before continuing with the discussion of the second pilot study, it is pertinent to point out that between the two pilot studies and after the second pilot study, this investigator had the opportunity to observe some in-service high school geometry teachers reporting the benefits of using the Geometer's Sketchpad in their classes in conferences on the use of technology in mathematics education. This investigator conjectured that there are two types of teachers: those who prefer the Geometric
Supposer, and those who prefer the Geometer's Sketchpad. The latter teachers may like the Geometer's Sketchpad because this software allows free exploration of geometrical shapes and facilitates discovery learning. These two different reactions toward these two pieces of geometry software attracted the attention of this investigator.

Figure 4 shows the means for each of the items of the Likert type scales for the Geometric Supposer and the Geometer's Sketchpad.

**Figure 4.** Potential Teaching Effectiveness of the Geometric Supposer and the Geometer's Sketchpad
Data suggest that if these teachers had to teach high school geometry with the use of computers, they would prefer to use the Geometric Supposer rather than the Geometer's Sketchpad. Once the data analysis was carried out, the results were reported to participating teachers. When they were asked why they preferred the Geometric Supposer over the Geometer's Sketchpad they explained that the Geometer's Sketchpad is not easy to learn and because of that it could be difficult to teach with this software because it could cause many students to require the teacher's attention to get into the software at the same time.

Based on the results of the two pilot studies reported above, the original assumption of the present study was: It is the software structure which determines the use of computers in education more than the computer itself. However, the results of the present study show that there are other factors that determine the uses of computers in education, for instance, the availability of computers—one for the whole class, or one computer for each student—and also personal preference of teachers for some methods of teaching. For instance, some teachers may adopt the current model of teacher-centered instruction when they use computers in their classes, no matter what type of software they use. Chapter 5 discusses some strategies to design computer environments that promote discovery and cooperative learning in schools.
Computer Software

Several factors that make the integration of computers into the classroom difficult have been reported, among which are the following:

a) Factors related to the quality of present educational software and the prospects for better quality software in the future (Self, 1987).

b) Factors that make computers fail to take hold in the schools, i.e., not enough hardware, the lack of good software, and inadequate training for teachers (Carlson, 1991).

c) Factors that affect classroom interactions, i.e., different types of software assume (and perhaps encourage) different patterns of control (Surgey, and Scrimshaw, 1987).

The first software, designed for education, was very structured provided few possibilities for free exploration of mathematical objects and relationships, and facilitated the control of the class (Surgey and Scrimshaw, 1987).

Statements (a), (b), (c), and the results of the two pilot studies led this investigator to look for factors that may determine teachers' preferred teaching strategies and evaluation procedures when planning to teach with Geometric Supposer and/or Geometer's Sketchpad. The first approach was to relate teachers' preferred teaching styles with selection and use of geometry
software. For this purpose, a teacher characterization based on Myers–Briggs Type Indicator (MBTI) research was used.

Rationale

The Curriculum and Evaluation Standards for School Mathematics and the Professional Standards for Teaching Mathematics proposed by the National Council of Teachers of Mathematics (1989, 1991) respectively, promote and favor a learning environment in which pupils explore, describe, and prove mathematical relationships and the teacher encourages students to share their ideas with the class.

The Professional Teaching Standards describes the major role of mathematics teachers as:

- Creating a classroom environment to support teaching and learning mathematics
- Setting goals and selecting or creating mathematical tasks to help students achieve these goals.
- Stimulating and managing classroom discourse so that students and teachers are clearer about what is being learned.
- Analyzing student learning, the mathematical tasks, and the environment in order to make ongoing instructional decisions.

The Curriculum and Evaluation Standards set new goals for students:
• Learning to value mathematics.
• Becoming confident in one's own ability.
• Becoming a mathematical problem solver.
• Learning to communicate mathematically.
• Learning to reason mathematically.

The question is whether the use of computers in classrooms will facilitate the implementation of the NCTM Standards or, in spite of using computers, will teachers tend to lecture students, as in the traditional classroom? The rationale for this study is the gap between the proposed models of computer uses in education and some of the current ways teachers use computers, for instance like the following that has been described by Thornburg (1989):

Some computer labs that I've seen look like a page from Orwell's 1984 as thirty or more students sit silently in front of machines where they are being moved, step by step, through activities in which the computer programs the learner.

The result is a student who knows that Springfield is the capitol of Illinois, but who has no idea why the capitol was located there, and, worse yet, has no inclination to even ask the question.

If this is the only kind of computing environment that students encounter, their creativity and natural curiosity
about the world will atrophy and we will have created a nation of automata. (p. 27)

Significance of the Study

There is an increasing need for incorporating Information Age technologies into school education. The National Council of Teachers of Mathematics has made this explicit in suggesting that students should have constant access to calculators and computers in schools. The *Curriculum and Evaluation Standards* promote the use of technology in schools in grades K–12 as the following quotation indicates:

Because technology is changing mathematics and its uses, we believe that:

- appropriate calculators should be available to all students at all times;
- a computer should be available in every classroom for demonstration purposes;
- every student should have access to a computer for individual and group work;
- students should learn to use the computer as a tool for processing information and performing calculations to investigate and solve problems. (National Council of Teachers of Mathematics, 1989, p. 8).
The need for implementing the use of information technologies in education makes urgent the creation of appropriate and effective systems for training mathematics teachers in the use of technology in education. It is desirable to identify specific characteristics of preservice teachers to design and provide instruction that enhances their natural teaching skills and favors their creativity and personal expression. The results of the present study may provide guidelines to mathematics student teachers for designing computer environments that encourage discovery learning with an emphasis on instruction that gives all students equal chance at success.
CHAPTER II
THEORETICAL FRAMEWORK AND LITERATURE REVIEW

You take the phenomenon under study and turn it around as if it's a sphere: Look at it from above, below, from many sides. In other words, you think comparatively along any of its dimensions. Think in terms of variation along the given dimension, say size, intensity, or flexibility. . . . With your instance of scientific anomalies, your research has led to distinctions among anomalies, mistakes and artifacts. And of course you now know the salient dimensions of each. So you can compare anomalies with mistakes and artifacts along different dimensions. (Strauss, 1987, p. 276).

On the one hand, psychology and mathematics education as research domains remained relatively disjoint until 1955 when Hans Freudenthal proposed including psychological considerations to respond to problems raised by mathematics education researchers (Fischbein, 1990). On the other hand, the psychology of mathematical activity as a domain of scientific investigation is relatively recent and the learning theories developed in this tradition have been mainly focused on cognitive processes. Mathematics education research reported in the proceedings of the International Group for the Psychology of Mathematics Education

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is based on cognitive psychology and "representation and process are the primary foci of all the cognitive disciplines" (Mandler, 1985, p. 10).

However, when researchers have tried to include feelings and emotions (e.g., fear, anxiety, attitudes, and so on) that may affect mathematics learning, cognitive psychology does not provide the appropriate theoretical framework as has been observed by Skemp, Fischbein, Contessa, and Mandler, among others.

Skemp (1987) points out that the separation of cognitive from affective processes is artificial and does not reflect human experience. Fischbein (1990) suggests that a theoretical model that considers only the logical steps is insufficient for predicting the solver's success when solving a problem in mathematics because success depends so much on experience, knowledge, intuition, attention, emotion, and so forth. Contessa (1981) observes that literature in educational research in the area of student cognitive development and learning has been devoted to examining the influence of cognitive factors and in spite of the theoretical and empirical linkages between student personality factors and learning "the literature relating these variables is meager" (p. 30). Contessa found that particular personality factors are related to level of cognitive development and suggests that "researchers should give more consideration to the effects of non-cognitive factors, specifically personality factors, upon cognitive
development in order to formulate a more comprehensive psychological theory of development" (p. 2). Mandler (1985) observes that although personality psychology is not part of cognitive psychology, this field of study is an "empirical gold mine" (p. 19) that can be tackled with innovative cognitive theories.

The foregoing discussion leads one to conclude that some areas of research in mathematics education, such as attitude towards mathematics and computers, would benefit from the inclusion of personality theories in the current theoretical framework of mathematics education research. Mandler (1989) observed that "affect is the least investigated aspect of human problem solving, yet it is probably the aspect most often mentioned as deserving further investigation" (p. 3). He says that emotions are tied to cognitive evaluations, that is, emotions are situation specific and subjective emotional states, but their source is tied to a cognitive evaluation that selects the appropriate emotion.

What is the mental representation that gives rise to judgments and feelings of good or bad or some affective nature in general? Surprisingly, psychologists have paid relatively little attention to problems of value, in the sense of developing a theory of the underlying structures that give rise to phenomenal experiences of value. (p. 7)
The preferred teaching strategies and evaluation methods of teachers reflect their understanding of how students learn. Teachers' selection of teaching strategies is based on a system of values. They determine the "best" teaching strategies to help students learn mathematics based on what they consider is "good" or "bad" for their students. The Theory of Types of Carl G. Jung suggests that besides cultural and social parameters, this system of values may also be related to mental structures that determine people's perceptions and ways of taking action, that is, their perception and judgment. According to Myers, and McCaulley (1985), "perception includes the many ways of becoming aware of things, people, events, or ideas. . . . Judgment includes all the ways of coming to conclusions about what has been perceived" (p. 12).

The personality theory that was selected to develop the theoretical framework of the present study was the Type Theory of Carl G. Jung. Jung's psychological functions can be related in some way to the stages of the director system of Skemp's intelligent learning model. In this way the interaction of affective and cognitive domains could be studied.

The purpose of this chapter is to give an introduction to Jung's theory of personality types and to describe the Myers–Briggs Type Indicator (MBTI) that allows determination of one's preferred Jungian psychological functions. The literature review focuses on
MBTI studies related to the problem of interest, that is: (1) Personality types of school teachers and of mathematics teachers; (2) Teaching styles of schoolteachers and school mathematics teachers; (3) Personality types of computer programmers; (4) Personality types of students; and (5) Interaction of student personality type with Computer Assisted Instruction (CAI). Consulted sources were published papers and unpublished dissertations reporting studies related to the present study.

Five sources were used to locate MBTI studies: (a) *Myers-Briggs Type Indicator: Atlas of Type Tables* (Macdaiid, G. P., McCaulley, M. H., and Kainz, R. I., 1986) this source contains an alphabetical listing of research and references to the Myers-Briggs Type Indicator as prepared and maintained by the staff of the Center for Applications of Psychological Type (CAPT), based on materials in the Isabel Briggs Myers Memorial Library which is housed at the CAPT, (b) *New Tools for MBTI Research* (Carskadon, 1987), (c) *Summary of Myers-Briggs Type Indicator Research Applications in Education* (Hoffman, and Bektowski, 1981), (d) *A Synthesis of Learning Style Research Involving the MBTI*, (Lawrence, 1984), and (e) the *Consulting Psychologist Press 1994 Catalog*. Professor McCaulley sent two lists of MBTI studies from the CAPT library at the researcher's request (see Appendix A).

Because just one MBTI study related to the characterization of computer programmers was located (Barnes, 1974), it was
necessary to include a qualitative study (Turkle, 1984) that, although based on a different research tradition, complements the schematic results based on the statistics obtained from the correlation of the MBTI personality types and the variables measured by other instruments. The methodology used to carry out the present study was taken from Glaser, and Strauss (1967). These authors have developed a methodology for social sciences which they call grounded theory. They observe that: "The sociologist whose purpose is to generate theory... is more likely to analyze previously collected data—called secondary analysis" (p. 187). Their methodology allows the use of quantitative and qualitative data: "Theoretical analysis of quantitative data is, of course, an opportunity to be taken by many sociologists" (p. 188). They explain:

Since populations are in constant change, we have no way of knowing whether a survey accomplished some years ago for other purposes still applies meaningfully to the specific population. This problem of accuracy is not as important for generating theory about a type of social unit as it is for describing a particular social unit or verifying a hypothesis. What are relevant for theory are the general categories and properties and the general relations between them that emerge from the data. (p. 189)
Introduction to Personality Type Theory

Jung (1971) observed that a personality type is the product of interactions between attitudes and mental functions. "The total result of my work in this field up to the present is the establishing of two general attitude-types, extroversion and introversion, and four function-types, thinking, feeling, sensation, and intuition. Each of these function-types varies according to the general attitude and thus eight variants are produced" (p. 540).

Although Sigmund Freud is considered the father of psychoanalysis, today psychoanalysis is just one theory among many of how mind works (Crooks, and Stein, 1991; Engler, 1985). Carl G. Jung was a student of Sigmund Freud and after their friendship broke up, Jung developed his own theory of personality which he called analytic psychology. Whereas Freud described the structure of personality in terms of three forces that are in constant conflict—the id, the ego, and the superego—Carl Jung conceived the structure of personality as a complex network of interacting systems that strive toward eventual harmony, that is, the ego, the personal unconscious with its complexes, and the collective unconscious and its archetypes. The ego is one's conscious perception of self. The personal unconscious contains those experiences that have been put aside and may be easily retrieved, it also contains those experiences of an individual's life
history that have been repressed or forgotten. Whereas the personal unconscious is unique for each individual, the collective unconscious is shared. All people, because they are human beings share certain emotions such as joy, grief, or anger. The ways of expressing these emotions may vary from society to society, but the emotions themselves are shared. The collective unconscious consists of predispositions or possibilities of behaving in certain ways because we are humans. Jung also talked about two primary attitudes and four basic functions, which together constitute separate but related aspects of the psyche, or total personality.

The significance of the attitudes and of the functions is that they deeply affect how we relate to the world and to other people. Freud and Jung emphasize the dynamic opposition of portions of the personality although they differ in the implications of this conflict. “For Freud, the person is inescapably in conflict; for Jung, the person ultimately seeks harmony” (Engler, 1985, p. 94).

According to Engler (1985), Jung criticized the contemporary scientific atmosphere for limiting its concepts to those of causality because the concepts of cause and goal are not themselves found in nature but are imaginary constructs imposed by scientists. Jung urged scientists to work within a broader scope and conceptual design. He did not believe that psychologists should be bound to an experimental, scientific approach. Consequently, scientific
psychology has until recently largely ignored Jung's analytical psychology.

Extension of Jung's Theory of Types

Katharine Briggs had started her own typology through the study of biography before she discovered Jung's theory of Types which she accepted and explored and elaborated. Her daughter, Isabel Briggs (who married Clarence Myers) absorbed her admiration of Jungian typology. Isabel Myers developed a method of making the theory of practical use. She developed the indicator that differentiates 16 personality types.

Note that while Jung refers to eight types, Myers, and Myers (1980) describe 16. This is because Jung identified two attitudes (Extrovert, Introvert) and four functions (Thinking, Feeling, Sensing, Intuitive) and Myers' categorization includes two other attitudes Perception and Judgment (Myers, and Myers, 1980; and Myers, and McCaulley, 1985). These two terms are implicit in Jung's theory but he did not use them to define his types.

Jung described extroversion-introversion (E-I), sensing-intuition (S-N), and thinking-feeling (T-F) explicitly in his work; the importance of judgment and perception was implicit in Jung's work, and was made explicit by Isabel Myers, and Katharine Briggs in the development of the MBTI. . . . The recognition and development of facts about the JP (judging-
perceiving] function are a major contribution of Briggs and Myers to the theory of psychological types. (Myers, and McCaulley, 1985, p. 13).

Myers, and McCaulley (1985) point out that:

To understand Jung's theory it is important to appreciate the critical importance of the uses of the terms perception and judgment. . . . Perception includes the many ways of becoming aware of things, people, events, or ideas. It includes information gathering, the seeking of sensation or of inspiration, and the selection of the stimulus to be attended to. . . . Judgment includes all the ways of coming to conclusions about what has been perceived. It includes decision making, evaluation, choice, and the selection of the response after perceiving the stimulus. (p. 12)

According to Myers, and Myers (1980), Jung divided all perceptive activities into two categories—sensing and intuition— and judgment activities into thinking and feeling. These authors describe how the Jungian functions—Sensing, Intuitive, Thinking, and Feeling—work. Table 1 contains Myers' description of these functions.
**Table 1.** Sensing, Intuitive, Thinking, and Feeling Functions

<table>
<thead>
<tr>
<th>Perception</th>
<th>Sensing Perception</th>
<th>Intuitive Perception</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensing [S] refers to perceptions by way of the senses.</td>
<td>Perception of possibilities, meanings, and relationships by way of insight. Jung characterized intuition as perception by way of the unconscious.</td>
</tr>
<tr>
<td></td>
<td>Sensing establishes what exists.</td>
<td>Intuitions may come to the surface of consciousness suddenly, the sudden perception of a pattern in seemingly unrelated events, or as a creative discovery.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intuition permits perception beyond what is visible to the senses.</td>
</tr>
<tr>
<td>Judgment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinking Judgment</td>
<td>Links ideas together by making logical connections.</td>
<td>Relies on principles of cause and effect and tends to be impersonal.</td>
</tr>
<tr>
<td>Feeling Judgment</td>
<td>The function by which one comes to decisions by weighing relative values and merits of the issues.</td>
<td>Relies on an understanding of personal values and group values.</td>
</tr>
</tbody>
</table>

Myers, and Myers (1980) see differences in mental functioning related to the way people prefer to use their minds, that is, the way they perceive and the way they make judgments (see Table 2).
Table 2. The Roles of the Perception and Judgment Attitudes and the Sensation, Intuition, Thinking, and Feeling Functions

<table>
<thead>
<tr>
<th>Perception</th>
<th>Sensation</th>
<th>Orients toward what is immediate and real.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intuition</td>
<td>Orients toward what is possible and imaginative.</td>
</tr>
<tr>
<td>Judgment</td>
<td>Thinking</td>
<td>Orients toward rational order and plans according to impersonal logic.</td>
</tr>
<tr>
<td></td>
<td>Feeling</td>
<td>Orients toward rational order according to harmony among subjective values.</td>
</tr>
</tbody>
</table>

Myers, and Myers (1980) refer to perceiving and judging as attitudes. They explain the differences between them and illustrates them with the following example:

Although people must of course use both perception and judgment, both cannot be used at the same moment. So people shift back and forth between the perceptive and judging attitudes, sometimes quite abruptly, as when a parent with a high tolerance for children's noise suddenly decides that enough is enough.

There is a fundamental opposition between the two attitudes. In order to come to a conclusion, people use the judging attitude and have to shut off perception for the time
being. All the evidence is in, and anything more is irrelevant and immaterial. The time has come to arrive at a verdict. Conversely, in the perceptive attitude people shut off judgment. Not all the evidence is in; new developments will occur. It is much too soon to do anything irrevocable . . . This preference makes the difference between the judging people, who order their lives, and the perceptive people, who just live them. (pp. 8–9)

It has been noticed above that there are differences between the theory of personality proposed by Jung and the theory behind the Myers-Briggs Type Indicator. In this respect, Pittenger (1993) points out that Myers, and Briggs' theory "ignores Jung's concepts of the unconscious and its relation to dominant and auxiliary functions, and the development of compensatory processes in the unconscious" (p. 469), and that the interpretation of the MBTI results without the broader themes of Jung's theory would appear to be potentially harmful.

Adaptability System

The integration of Jung's Type theory and the Skemp's description of intelligent learning may allow the development of a model that facilitates the study of affective and cognitive interactions and processes. This section describes how Jung's
functions may be integrated with Skemp's model of a director system.

On the one hand, Skemp (1987) describes intelligent learning as part of the adaptation process: "We, as members of the species *homo sapiens*, are the most adaptable [underlined added] species of any; and what gives us this adaptability is an ability to learn in a particular way, which I call *intelligent learning*. The ability itself I call *intelligence*" (p. 105). On the other hand, Crooks, and Stein (1991) define personality as: "The study of individuals—their distinctive characteristics and traits and the manner in which they integrate all aspects of their psychological functioning as they adapt [underlined added] to their environments" (pp. 513–514). Both definitions, Skemp's, and Crooks, and Stein's, refer to the adaptability of human beings. The approach of Skemp is generic, that is, he refers to all human beings without distinguishing differences among individuals; while Crooks, and Stein's focuses on the characteristics of individuals. Adaptability can be the key term that allows to study cognitive and affective processes jointly. The Skemp's definition of intelligent learning and the definition of personality of Crooks, and Stein suggest that the adaptability system may be the intersection of the cognitive domain and the affective domain (see Figure 5).
Figure 5. Adaptability System

Figure 6 illustrates how the Jungian functions could be located within the Skemp's director system.

Figure 6. Representation of the Adaptability System

The Theory of Types of Carl Jung facilitates the integration of cognitive and affective domains because studies the interactions among mental functions that are related to cognitive and affective
process, for instance the Thinking and Feeling functions. Skemp relates intelligence and adaptability in his model of goal-directed learning through his idea of a director system. He describes the director system as follows:

We need a sensor, which takes information about the present state of the operand, and represents it internally. We need an internal representation of the goal state. We need a comparator to compare these. And we need a plan of action: what we actually do to change the state of the operand from its present state to the goal state. (Skemp, 1987, pp. 105–106).

The model of the adaptability system developed for the present study (see Figure 6) is based on the model of the director system described by Skemp (1987) in his book Psychology of Learning Mathematics. He borrowed a model from cybernetics to explain his idea of intelligent learning. His description of mental processes may resemble the programmed steps followed by a machine to get a task done (the goal state). When the Jungian functions are incorporated into the director system's stages, the model acquires some human characteristics.

Human beings have some ideals to achieve and set themselves goals to approach these ideals. Where these ideals come from?, and Why do we try to reach them?—Try to answer these questions
is beyond the scope of this study. However, the adaptability system that is being described is seen as a "mediator" between social and personal demands. Human beings may use this adaptability system for different purposes, for instance, to make sense out of our experiences, to create inner equilibrium, to organize our actions to reach goals, and so on. Different situations and contexts will require the use of different Jungian functions but their role could be described schematically as elements or stages of a whole process like the intelligent learning described by Skemp (1987). Although instead of a "sensor," we have ways of perceiving through the Sensing and the Intuitive functions. Instead of a "comparator" we have an evaluator, and we may use the Thinking or the Feeling functions to evaluate the incomes (i.e., experiences). Based on Perception or Judgment we may decide whether we need more information (and more planning is needed) or whether we can decide and take action. The double arrows suggest a double interaction between the subject and the object of learning. Understanding does not come from a passive contemplation of nature but rather from active interaction with objects. We plan based on our experience, and our experience also determines our perceptions.

Table 3 illustrates how the Jungian functions may be related to the Skemp's director system and then to his theory of intelligent learning using the Myers, and Briggs' extension of Jung's Theory of
Types. The MBTI studies related to learning styles included in this chapter will provide a wider view of how the preference for the Sensing or the Intuitive function may affect learning.

**Table 3. Integration of Jung's, Skemp's, and Myers' Theories**

<table>
<thead>
<tr>
<th>Skemp's Dynamic System Elements</th>
<th>Jungian Psychological Functions</th>
<th>Myers' Description of Jungian Psychological Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensor</strong></td>
<td><strong>Sensing Perception</strong></td>
<td>This function refers to perceptions by way of senses.</td>
</tr>
<tr>
<td></td>
<td><strong>Intuitive Perception</strong></td>
<td>This function refers to perception of possibilities, meanings, and relationships by way of insight. Perception by way of the unconscious.</td>
</tr>
<tr>
<td><strong>Comparator</strong></td>
<td><strong>Thinking Judgment</strong></td>
<td>Thinking is the function that links ideas together by making logical connections.</td>
</tr>
<tr>
<td></td>
<td><strong>Feeling Judgment</strong></td>
<td>Feeling is the function by which one comes to decisions by weighing relative values and merits of the issues.</td>
</tr>
<tr>
<td><strong>Action</strong></td>
<td><strong>Perception</strong></td>
<td>Perception includes the many ways of becoming aware of things, people, events, or ideas. It includes information gathering, the seeking of sensation or of inspiration, and the selection of the stimulus to be attended to.</td>
</tr>
<tr>
<td></td>
<td><strong>Judgment</strong></td>
<td>Judgment includes all the ways of coming to conclusions about what has been perceived. It includes decision making, evaluation, choice, and the selection of the response after perceiving the stimulus.</td>
</tr>
</tbody>
</table>

Although cognitive and personality theories correspond to different areas of study, the subject of their analysis is the same in both cases: the human mind. The need of each individual to
adapt to different environments is present in any culture and this process may be studied from different perspectives. The adaptability system is part of both the cognitive and affective domains. Different mental functions are interconnected in this system and play an important role in cognitive development. For instance, Myers, and Myers (1980) observe that:

The most conspicuous relationship between type and education lies in the apparent advantage enjoyed by intuitives in most academic fields. They gravitate into higher education. . . . Both high scholastic aptitude and interest are found most often among intuitives. This is more than a fact. It is a promising clue to the mechanics of learning. What do intuitive children do, that makes learning easier and more interesting? How could more children be helped to do it? (p. 137)

The adaptability system may be related to personality type. Keirsey, and Bates (1978) describe a person whose personality type is characterized for creating and fostering the continuity of social units. They observe that:

The institutions call him and he comes to them to establish them, nurture them, and maintain their continuity and perpetuity. Teaching, preaching, accounting, banking, clerking, medicating,
rehabilitating, securing, insuring, managing, selling—note in all of these a single strand of desire: to conserve." (p. 43)

The results of the present study show that the participating student teacher with this personality type may not accept easily curricular changes. He wants to adapt the use of computers to the traditional method of teaching and curriculum. He may have difficulties to adapt to a computer environment that encourages problem solving with an inquiry approach and that favors cooperative learning. Later in this chapter will be observed that this personality type is very common in the population of school mathematics teachers.

The Myers–Briggs Type Indicator

The Myers–Briggs Type Indicator (MBTI) is based on Jung's theory of psychological types. During the past 30 years, there has been an increase in the use of the MBTI in a variety of settings. There is also a large body of research that examines the validity of the test. This section includes some issues related to the development of the Indicator and its validity and reliability and it describes how the MBTI scores are interpreted.

Issues in the Development of the MBTI

The courage, time invested, and energy that Katharine Briggs and Isabel Myers' work shows can be compared with Marie Curie's. The Indicator project was essentially the work of Isabel Myers, based upon the theoretical foundation laid by her mother's
extension of Jung's theory of types. Lawrence (1986) describes some issues in the development of the MBTI and he points out that:

In the 1940s psychological testing was still new, and personality testing even newer. Norms and standards were uncertain, and exemplary tests were few. Isabel Myers knew that the community of psychologists would give a skeptical critique to any new instrument. Looking back, one has to wonder about the odds of success of an instrument devised by a woman who was not a psychologist, had no formal education beyond a bachelor's degree in political science, and was trying to represent a theory by a psychologist whose work was not credible to most American psychologists [Carl G. Jung]. Having no training in statistics and test construction, she intended to learn the craft so thoroughly and apply it so carefully that she could anticipate any issues that might be raised by other researchers about the validity, reliability, and psychometric properties of the Indicator. (p. 3)

Lawrence observes that personality and educational instruments most commonly identify the quantity of a trait or skill that the respondent has whereas the MBTI sorts people into the theoretical categories of type. Since most literature on test
construction was concerned with measuring the skillfulness of a performance or the strength of a trait, Isabel Myers "had to break new ground in instrument development and to justify her innovations" (p. 4).

The MBTI was designed to implement Jung's theory of psychological types. In terms of the theory, a person may be expected to develop most skill in the processes a person prefers to use and in the preferred areas of using them. It also should be mentioned that the Indicator attaches no value judgments to one preference as compared with another but considers each one valuable and at times indispensable in its own field (Myers, and McCaulley, 1985).

The Indicator contains four separate dichotomous categories which are called basic preferences indices (see Table 4). Under this theory, these indices show the structure of the individual's personality. Test results identify 16 types (see Table 5). A short portrait of the 16 personality types is given in Appendix B and a review of the main characteristics of each type will ease the reading of the following sections.
Table 4. Basic Preferences Indices

<table>
<thead>
<tr>
<th>Index</th>
<th>Preferences Between</th>
</tr>
</thead>
<tbody>
<tr>
<td>EI</td>
<td>Extroversion or Introversion</td>
</tr>
<tr>
<td>SN</td>
<td>Sensing or Intuitive</td>
</tr>
<tr>
<td>TF</td>
<td>Thinking or Feeling</td>
</tr>
<tr>
<td>JP</td>
<td>Judging or Perceptive</td>
</tr>
</tbody>
</table>

Table 5. The Sixteen Jungian Personality Types

<table>
<thead>
<tr>
<th>ENTJ</th>
<th>INTJ</th>
<th>ESTJ</th>
<th>ISTJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENTP</td>
<td>INTP</td>
<td>ESTP</td>
<td>ISTP</td>
</tr>
<tr>
<td>ENFJ</td>
<td>INFJ</td>
<td>ESFJ</td>
<td>ISFJ</td>
</tr>
<tr>
<td>ENFP</td>
<td>INFP</td>
<td>ESFP</td>
<td>ISFP</td>
</tr>
</tbody>
</table>

MBTI Validity and Reliability

The MBTI shows strong correlation with other measures of personality, psychological types, and interest. Correlation has been shown between the MBTI and the following: The Gray-Wheelwright Psychological Type Questionnaire, the Strong Vocational Interest Blank, the Allport-Vernon-Lindzey Study of Values, the Edwards Personal Preference Schedule, and the
Personality Research Inventory. All the above are discussed in detail in Myers, and McCaulley (1985). The reliability of the MBTI was determined by split-half, and test re-test procedures. Myers, and McCaulley (1985) report creditable reliability indices. (Appendix C contains the reliability indices for each of the MBTI scales reported for the for G of the indicator).

However, although the indicator may be considered reliable, its validity has been discussed. For instance, Pittenger (1993) reports the results of a "unified view" of test validity which requires many sources of corroboration. Previous procedures focus on single validation procedures (e.g., construct validation). He claims that there is insufficient evidence to support the tenets of, and claims about, the utility of the test for counseling. However, he observes that "there is ample evidence . . . that segments of the test can be used to make general predictions" (p. 483). He points out that "the current technical and popular literature also presents the MBTI type as a static deterministic construct" (p. 482), while personality theories do not consider personality as static and deterministic construct. Crooks, and Stein (1988) point out that:

Although personality psychologists have not reached a general consensus on a formal definition of personality, a common theme can be found in most definitions. . . . "personality usually refers to the distinctive patterns of behavior (including
thoughts and emotions) that characterize each individual’s adaptation [italics added] to the situations of his, her life”

...We may best describe personality psychology as the study of individuals—their distinctive characteristics and traits and the manner in which they integrate all aspects of their psychological functioning as they adapt [italics added] to their environments. (pp. 513–514)

Personality is the result of cognitive and affective interactions. It is a dynamic system that we use to adapt ourselves to different situations. MBTI studies suggest that preferred teaching strategies, teaching styles, and evaluation methods may be related to personality type. It seems that some MBTI types of teachers may have some natural preference for inquiry approaches, so these teachers may adapt easily their preferred teaching strategies to the teaching strategies that the NCTM Curriculum and Evaluation Standards and the Professional Teaching Standards advocate. The present study explores how preservice teachers may adapt their preferred teaching strategies when they plan to teach high school geometry with the Geometer’s Sketchpad and/or the Geometric Supposer.

Interpretation of MBTI Scores

Myers, and McCaulley (1985) describe the Indicator as follows:

"The main objective of the MBTI is to identify four basic
preferences . . . every person is assumed to use both poles of each of the four preferences, but to respond first or most often with the preferred functions or attitudes" (p. 3). They point out that the scales were not designed for measurement of traits or behaviors. The MBTI items scored for each index offer forced choices between the poles of the preference at issue (see Table 6).

Table 6 Sample of Function Scale Items of the MBTI

| Extroversion or Introversion [E-I] | 1. Are you usually  
a) a "good mixer," or  
b) rather quiet and reserved? |
|----------------------------------|---------------------------------------------------------------------|
| Sensing or Intuitive [S-N]       | 2. If you were a teacher, would you rather teach  
a) fact courses, or  
b) courses involving theory? |
| Feeling or Thinking [F-T]        | 3. Do you more often let  
a) your heart rule your head, or  
b) your head rule your heart? |
| Judging or Perceiving [J-P]      | 4. When you go somewhere for the day, would you rather  
a) plan what you will do and when, or  
b) just go? |

Each of the responses for a question may be weighted 0, 1, or 2 points. Technical details of item construction, weighting, and prediction ratios are given in Chapter 9 of the Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator. The letters indicate the direction of the preference, the number indicates the strength of the preference. Chapter 3 of the MBTI
Manual includes a characterization of each of the 16 types (see Appendix B). According to Myers, and McCaulley (1985), the most frequent error that occurs when interpreting the numerical portion of MBTI scores is assuming that strength of preference implies excellence. It is not correct to assume that a person scoring 41 in N has developed intuition skills more effectively than the person reporting a score of 9. They point out that "a larger score simply means that the respondent, when forced to choose, is more clear about what he or she prefers" (p. 58).

MBTI Studies

The MBTI characterization of teaching and learning styles was selected among others—Dunn, R., and Dunn, K., 1979; Gregorc, A. F., 1979; Heimlich, 1990; Oltman, P. K., Raskin, E., and Witkin, H. A., 1971; Sugarman, 1985—because the Jungian psychological functions could be integrated to the Skemp's director system, as was illustrated above.

Hoffman, and Betkouski (1981) provide a synthesis of MBTI studies in education. Their *Summary of MBTI Research Applications in Education* is focused on the "identities of persons who choose teaching as a career, the possible differences in personality types of teachers of varying sex, grade level and subject areas, certain characteristics of effective teaching, and whether any personality factors affect the interaction of teachers with the student teachers they supervise" (p. 3).
This section describes MBTI studies that: (1) Characterize schoolteachers; (2) School mathematics teachers; (3) Computer programmers; (4) Students; (5) Interactions of Computer Assisted Instruction and students' personality types; and (6) Estimated frequencies of MBTI types.

Schoolteachers

Systematic observation of classroom interactions has been used in looking at teaching styles and their effects. This section first presents three characterization of schoolteachers. Second, the characteristics of the most common types of schoolteachers are indicated. Finally, school mathematics teachers' characteristics are described.

Three Characterizations of Schoolteachers

Keirsey, and Bates (1978), Myers, and McCaulley (1985), and Silver, and Hanson (1985) have identified four types of teachers. They have categorized the preferred teaching styles, teaching strategies, and/or evaluation methods of these teachers. These authors have observed that teachers who have similar preferences for Jungian functions tend to use the same teaching strategies and evaluation methods.

Keirsey, and Bates (1978). Under the Katharine Briggs' extended theory of types, the ST and SF types observed by Myers, and McCaulley (1985), and Silver, and Hanson (1985) correspond to the SJ and SP types respectively of Keirsey, and Bates (1978)
(Myers, and Myers, 1980). Table 7 contains the schoolteachers' characterization given by these authors.

**Table 7** Keirsey, and Bates' Schoolteacher Characterization

<table>
<thead>
<tr>
<th>Preferred Functions</th>
<th>Instructional Techniques</th>
<th>Prime Value in Education</th>
</tr>
</thead>
</table>
| Sensing–Perceiving  | • Projects  
| (SP)                | • Contests  
|                     | • Games  
|                     | • Demonstrations  
|                     | • Shows  
|                     | • Growth of Spontaneity  
|                     | and Freedom  |
| Sensing–Judging     | • Recitation  
| (SJ)                | • Drill  
|                     | • Composition  
|                     | • Test/Quizzes  
|                     | • Demonstration  
|                     | • Growth of Responsibility  
|                     | and Utility  |
| Intuitive–Thinking  | • Lectures  
| (NT)                | • Tests  
|                     | • Compositions  
|                     | • Projects  
|                     | • Reports  
|                     | • Growth of Knowledge and Skills  |
| Intuitive–Feeling   | • Group Projects  
| (NF)                | • Interaction  
|                     | • Discussion  
|                     | • Shows  
|                     | • Simulations  
|                     | • Games  
|                     | • Growth of Identity and Integrity  |

Their book, *Please Understand Me*, is not a review of research using the MBTI, though most of its conclusions tend to be supported by the studies reviewed by Hoffman, and Betkouski. According to Hoffman, and Betkouski (1981), Keirsey's views "are derived partly from his observations of people through the lens of Jungian typology as carried out in his clinical practice" (p. 5). These authors have observed that there are two types of teachers who tend to make up the bulk of K–12 public school teachers, namely, Sensing–Judging types (SJ) and Intuitive–Feeling types.
Later in this chapter some studies reporting the preferred teaching styles of Sensing and Intuitive schoolteachers will be described.

Silver, and Hanson (1985). These authors suggest that the MBTI can be used as "a practical tool for examining personality type and its implications for analyzing teaching and learning behaviors" (p. 18). They provide a chart that teachers may use as "a ready reference for making matches, utilizing learning styles in curriculum planning, for the selection of teaching strategies" (p. 18). Appendix D contains the complete categories and subcategories used by these authors. Table 8 contains the teachers' characterization as described by them.

**Table 8 Silver, and Hanson's Schoolteacher Characterization**

<table>
<thead>
<tr>
<th>Preferred Functions</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing-Thinking</td>
<td>Trainers</td>
</tr>
<tr>
<td>[ST]</td>
<td>Information Givers</td>
</tr>
<tr>
<td></td>
<td>Instructional Managers</td>
</tr>
<tr>
<td>Sensing-Feeling</td>
<td>Nurturers</td>
</tr>
<tr>
<td>[SF]</td>
<td>Supporters</td>
</tr>
<tr>
<td></td>
<td>Empathizers</td>
</tr>
<tr>
<td>Intuitive-Feeling</td>
<td>Facilitators</td>
</tr>
<tr>
<td>[NF]</td>
<td>Stimulators</td>
</tr>
<tr>
<td></td>
<td>Creators</td>
</tr>
<tr>
<td></td>
<td>Originators</td>
</tr>
<tr>
<td>Intuitive-Thinking</td>
<td>Intellectual Challengers</td>
</tr>
<tr>
<td>[NT]</td>
<td>Inquirers</td>
</tr>
<tr>
<td></td>
<td>Theoreticians</td>
</tr>
</tbody>
</table>
Myers, and McCaulley (1985). The Myers, and McCaulley's
categorization of preferred roles of teachers was based on a review
of MBTI studies.

Table 8 contains Myers, and McCaulley's characterization of
four types of teachers.

**Table 9** Myers, and McCaulley's Schoolteacher Characterization

<table>
<thead>
<tr>
<th></th>
<th>The role of the teacher is to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing–Thinking [ST]</td>
<td>Set an example for students, be a role model, and share knowledge and experience.</td>
</tr>
<tr>
<td>Sensing–Feeling [SF]</td>
<td>Instruct, discipline, encourage, support, role model, and serve others.</td>
</tr>
<tr>
<td>Intuitive–Feeling [NF]</td>
<td>Encourage, inspire, provide variety and creativity and motivate students to develop.</td>
</tr>
<tr>
<td>Intuitive–Thinking [NT]</td>
<td>Encourage, inspire, help students develop as citizens and persons.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Ideas for teaching come from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing–Thinking [ST]</td>
<td>State and local curriculum guides, textbooks, and experience.</td>
</tr>
<tr>
<td>Sensing–Feeling [SF]</td>
<td>Curriculum guides, manuals, textbooks, workshops, other teachers, and experience.</td>
</tr>
<tr>
<td>Intuitive–Feeling [NF]</td>
<td>Concepts from content of subject taught, courses, reading, knowledge of student development, and ideas from everywhere.</td>
</tr>
<tr>
<td>Intuitive–Thinking [NT]</td>
<td>Concepts from subject area, knowledge of students' needs and developments, synthesis of ideas from many sources.</td>
</tr>
</tbody>
</table>
The Silver, and Hanson's descriptors were used in this study to categorized the preferred teaching strategies, and evaluation methods of four student teachers which will be reported in Chapter 4.

Schoolteachers

Silver, and Hanson (1985) point out that "Some authors have treated the functions in isolation from one another, whereas others, at Jung's suggestion, have paired the functions for a more comprehensive view of behavior" (p. 18). Among the pair of functions that have been studied are: Extrovert-Introvert [EI] (Lucasse, 1971, quoted in Hoffman, and Betkouski, 1981), Feeling-Thinking [FT] (DeNovellis, and Lawrence, 1983), Sensing-Intuitive [SN] (Hoffman, 1974; and Story, 1972).

Keirsey, and Bates (1978). These authors report that: (a) Sensing-Perceiving teachers comprises 4 percent of the schoolteacher population, (b) Sensing-Judging types, 56 percent, (c) Intuitive-Thinking, 8 percent, and (d) Intuitive-Feeling types, 32 percent. Sensing-Judging types are the majority in schools. They have noted that SJ teachers are: responsible, dependable, contributing to the needs of others, and creating and preserving social harmony. While the primary goal of the NF teacher is the search for self, through achieving identity and integrity.
Hoffman, and Betkouski (1981). These authors report that the modal (or most common) type for teachers is Extrovert-Sensing-Feeling-Judging. They describe this type of teacher as follows:

Exceptionally dependable, thorough, conscientious, systematic, hard working, and expecting others to be the same. They have a respect for facts, are patient with detail and routine, being generally practical, realistic, concerned with the here and now. They are friendly, tactful, and sympathetic, radiating warmth and fellowship. A very high priority is placed on harmonious human contacts. They think best when talking to people and enjoy talk. Preferring to have matters settled and decided, they first judge everything by a personal set of values, but they do not need or want to make all the decisions themselves. They are particularly warmed by approval and so work best with plenty of encouragement and praise. Showing loyalty to respected persons, institutions and causes, their main interest is in things that directly and visibly affect people's lives. (p. 4)

DeNovellis, and Lawrence (1983). These authors conducted systematic observations of the classrooms of middle school teachers as part of a project to validate new teacher training materials. They observed that teachers with similar personalities used similar teaching techniques. Teachers' personalities
promoted different behaviors in students. They compared the
classes of Sensing and Intuitive teachers, and compared the
classes of Feeling and Thinking teachers. The results of comparing
classes of Sensing and Intuitive teachers were as follows:

The classrooms of Sensing teachers were . . . more teacher
centered and characterized by pupil no-choice activities.
Whereas Sensing and Intuitive teachers' classrooms did not
differ in the amount of productive activity of students, their
students did behave differently when they were off-task; in the
Sensing teachers' classrooms significantly more students went
off-task in passive or withdrawn ways—such as doodling and
day dreaming. In contrast, the classrooms of Intuitive teachers
were more pupil centered (but not at the .05 level of
significance), with the teacher moving freely around the room
and attending pupils briefly (as contrasted with attending
closely). This instruction pattern apparently encouraged not
only pupil choice but pupil self-expression in that hostile—
aggressive pupil behavior was significantly higher in these
classrooms, and the Intuitive teachers showed significantly
more negative affect (non-verbal) than Sensing teachers. Note
that categories called hostile-aggressive and passive-withdrawn
include mild behaviors as well as the more severe. (p. 43)
The results of comparing classes of Feeling teachers with classes of Thinking teachers were as follows:

Feeling-type teachers differed significantly from Thinking types in scoring higher in these categories: having pupils work independently, attending pupils closely, attending simultaneous activities, and having activities that are pupil centered. Feeling teachers exhibited significantly more affect than did Thinking teachers. Whereas they did not differ in verbal negative affect, the Feeling types showed more non-verbal negative affect and more verbal and non-verbal positive affect. (p. 43)

These authors point out that "systematic observation has a role to play in further research on personality type" (p. 45). They conclude that "teacher type is a variable that makes a measurable difference in classroom dynamics" (p. 45).

**School Mathematics Teachers**

Above was observed that Sensing-Judging types are the majority in schools. The studies reported in this section suggest that in the mathematics schoolteacher population the proportion of this type of teachers may be even greater.

**Story (1972).** This author has investigated relationships between personality characteristics of mathematics teachers and
certain aspects of mathematics teaching. Story found that: (1) Mathematics teachers have a personality type distribution that differs greatly not only from people in other occupational groups, but also from other teachers. "Mathematics teachers tend to have a larger than normally expected number of Sensing–Judging personality types" (p. 67), (2) Preservice teachers are different in personality type from inservice teachers; 38% of the teachers were Intuitive types as compared to 51% for the preservice sample; the inservice teacher sample has 37% Feeling types, whereas the preservice sample was 63% Feeling types, (3) Intuitive teachers tend to choose college-bound courses and correspondingly higher grade levels; Sensing teachers tend to choose non-college-bound courses and correspondingly lower grade levels, (4) There is an indication that the percentage of Intuitive teachers increases as one goes to higher grade levels, (5) Sensing and Intuitive teachers prefer different types of students in their classrooms. There is an overall tendency to prefer Intuitive students, but a definite lack of preference for Sensing characteristics on the part of Intuitive teachers should be noted, (6) Finally, 82% of all teachers had used manipulative materials. Of this 82%, approximately 60% of the teachers rated their experience "good" and about 40% rated it "fair". There was more usage of manipulatives materials among Extroverts, and Extroverted Intuitive teachers rated it better than any other types.
Rudisill (1972). This author has investigated the relationships between mathematics teachers' personality type and their preferences for particular teaching strategies. Four teaching strategies were presented in the study: (a) lecture or expository method, (b) questioning techniques, (c) laboratory approach, and (d) self-paced instruction. The results of the study were as follows: (1) Inservice mathematics teachers rated the laboratory approach higher for its "overall value" than they did for its "personal usefulness," (2) Sensing mathematics teachers gave higher mean ratings to the laboratory approach than did the Intuitive teachers for its "overall value" and "how students feel" statements about the strategy, (3) Extrovert mathematics teachers gave higher mean ratings to the laboratory approach for its "personal usefulness" than did the Introvert teachers, (4) Extrovert mathematics teachers gave higher mean ratings to self-paced instruction than did the Introvert teachers on "personal usefulness," "overall value," and "how students feel" statements concerning the strategy, (5) Perceptive mathematics teachers gave higher mean ratings to questioning techniques for its personal usefulness than did Judging teachers, (6) Male mathematics teachers rated the personal usefulness of self-paced instruction higher than did female mathematics teachers.

Rudisill suggests that "research should be done which examines the observed strategies used in the classrooms. Teachers
who effectively use just one strategy should be tested to see if there are others of the same personality type who also prefer the consistent use of a single strategy" (p. 81).

**Personality Types of Computer Programmers**

This section describes two studies which portray the personality of computer programmers. Barnes' study, based on a statistical analysis, and Turkle's ethnographic study arrive to similar results. The main difference between these two studies is that one is quantitative and the other uses a qualitative approach. Barnes describes the mean of a group that might not correspond to all subjects in her sample, whereas Turkle built her study up interviewing students in the Massachusetts Institute of Technology (MIT). The following two quotations illustrate the characteristics of both studies: "It should be noted, however, that what was true for the group was not necessarily true for every individual. (Barnes, 1974, p. 98) and that "from hundred of cases [persons], patterns emerge which support generalizations. (Turkle, 1984, p. 318). What Barnes has observed was noticed before by Jung (1958) who wrote as follows:

Any theory based on experience is necessarily statistical; that is to say, it formulates an ideal average which abolishes all exceptions at either end of the scale and replaces them by an abstract mean. This mean is quite valid, though it need not
necessarily occur in reality. Despite this, it figures in the theory as an unassailable fundamental fact. (p. 8)

The result of combining the perspectives of these two studies belonging to different research traditions, allowed an outside and inside view of the computer programmer culture. Barnes' quantitative study took data from several sites and obtained similar results in all of them. However, what Barnes reports coincides with what Turkle found in her one-site study. The quantitative study describes the computer programmer culture from outside, giving a panoramic perspective of the whole group. The qualitative study describes the culture of the computer programmers from inside, providing details that add the human perspective to the quantitative description and highlighting the complexity of relationships among humans and between humans and machines.

Barnes (1974) looked for personality characteristics that tend to be common to selected computer programmers and programmer trainees and observed whether the personality characteristics of computer programmers differ significantly from those of selected computer programmer trainees. The programmers in the study were volunteers from the Auburn University Computer Center, the Office of Administrative Data Processing at Auburn University, and the University of Tennessee Computing Center who had been
employed as computer programmers at least three months. The
trainees in the study were volunteer students enrolled in Advanced
Assembler course at Auburn University, and volunteer
programmers who had been employed by the Auburn University
Computer Center less than three months. There were 34
programmers and 25 programmer trainees. All subjects were
administered the Minnesota Multiphasic Personality Inventory, the
Strong Vocational Interest Blank for Men, The Myers–Briggs Type
Indicator, and a Biographical Inventory. Data were analyzed by
constructing histograms, calculating means and standard
deviations, computing two-factor analyses of variance, and
correlation matrices.

Barnes found that, in general, programmers and programmer
trainees had similar characteristics and that they were: (1)
interested in mathematics, nature, and music, (2) not interested in
public speaking, law/politics, business management, sales,
military activities, technical supervision, or religious activities, (3)
likely to be Introverted with Thinking and Intuition as their most
highly developed functions [INT types], (4) most likely to be young
(age 20–25), single males who are the oldest child in their family.
She summarizes as follows:

In summary, these programmers and programmer trainees
might be described as quiet, reserved, independent, confident,
introverted, logical, and analytical. They seemed to mix optimism and pessimism, to respect others with little involvement, to organize work and personal lives, and to prefer theoretical, rather than social, interests. (pp. 102–103)

Barnes suggests that the characteristics of programmers and programmer trainees may indicate that "they are interested in private, creative, natural activities as opposed to public, authoritative, commercial activities" (p. 98).

On the other hand, Turkle (1984) studied people's relationships with the computer and how these relationships themselves become building blocks of culture at the Massachusetts Institute of Technology. She worked six years on her book The Second Self: Computers and the Human Spirit. The style of inquiry in this work is ethnographic. She is both a sociologist and a clinical psychologist. She describes her study as follows: "This kind of study of the role of ideas is not a survey of opinion on psychoanalysis or computation. I am interested in thoughts and feelings that are often not articulated as stable opinions or preferences" (p. 318). She mentions that, although her desire to understand ideas about mind—"those which the individual uses to think and work through his or her own situation" (p. 318)—influenced her choice for a clinical interviewing style, she is not interested in individual psychology. She points out that:
From hundreds of cases, patterns emerge which support generalizations about the cultural implications of the presence of psychoanalytic and computational ideas in everyday life . . . Ideas about mind, like ideas about anything else, are not transported directly from the professionals who develop them to the waiting individual. These ideas are mediated by family, friends, business acquaintances, and most significantly, by the social groups to which an individual belongs. (p. 318)

In her chapter Hackers: Loving the Machine for Itself, Turkle describes the hacker culture and its actors. She observes that "the hacker culture appears to be made up of people who need to avoid complicated social situations, who for one reason or another got frightened off or hurt too badly by the risks and complexities of relationships" (p. 216). She also noticed that:

It is a culture of people who leave each other a great deal of psychological space. It is a culture of people who have grown up thinking of themselves as different, apart, and who have a commitment to what one hacker described as "an ethic of total toleration for anything that in the real world would be considered strange." Dress, personal appearance, personal hygiene, when you sleep and when you wake, what you eat,
where you live, whom you frequent—there are no rules.
(p. 213)

Turkle, like Barnes, noticed that computer programmers were interested in music. However, Turkle goes deeper and she does not report just the fact that "computer programmers are interested in music" but she can say what type of music and why they find it fascinating:

There is a strong music culture within the hacker community. Yet it is one where preference rarely moves out of the Baroque. The hacker's computational aesthetic with its emphasis on intricacy of structure carries over to musical taste. Musical hackers are intrigued by the contrapuntal complexity many see as "mathematical," by the purity of compositional forms that depend less obviously on tonal color and drama for their effect. (p. 219)

Turkle also reports that the persons she observed were devoted readers of science fiction. One of the students she interviewed describes why he likes science fiction books:

In science fiction you can start from scratch. It's like writing a program. Even in Logo programming, children can create
worlds that operate by Aristotelian principles instead of
Newtonian ones. No physical constraints. Make a whole new
world with its own rules. (p. 222)

Gender differences is another factor missing in Barnes (1974).
On this issue, Turkle observed that:

There are few women hackers. This is a male world. Though
hackers would deny that theirs is a macho culture, the
preoccupation with winning and of subjecting oneself to
increasingly violent tests makes their world peculiarly male in
spirit, peculiarly unfriendly to women. (p. 210)

In this chapter, Turkle continues the detailed description of the
hacker's culture. She provides a very vivid characterization of
people sharing that culture. What is clear from Turkle's
description is that these persons are having a great problem
dealing with people and that they don't share the social values of
that culture outside which common people share. A question
arises here: What are the values and the world view of those who
design educational software that our children and young people
use in schools?

The results of the two studies reported in this section converge
in the computer programmer characterization though they come
from very different research traditions. What is clear is that the personality type of computer programmers is fairly specific. The results of Barnes' study suggest that Intuitive–Thinking [NT] is the personality type of computer programmers.

Keirsey, and Bates (1978) observe that Intuitive–Thinking [NT] types are: "Rather infrequent, only about 12 percent of the population or some 24 million people. In school, before there are selective factors operating, only four in a class of 32 would be NTs" (p. 47). These authors note that "an entirely different social environment surrounds the NTs. They must live with aliens, while the SPs and SJs are continuously surrounded by their own kind" (p. 47). The results of MBTI studies reported later in this section show that N and S types prefer different learning styles.

Differences between Intuitive and Sensing teachers were listed above, differences between Intuitives' leaning styles and Sensings' leaning styles will be described in the following section. Intuitive–Thinking [NT] types hold a different set of values than Sensing types. They perceive world and social relationships in a different way. Because of the characterization of Intuitive and Sensing types, it does not seem reasonable to expect that Intuitive–Thinking [NT] types may design computer environments where S types feel comfortable, or vice versa.
Students' Personality Types

Previous sections have described personality types and teaching styles of schoolteachers and mathematics teachers as well as the personality of computer programmers. This section is devoted to students' personality types and preferred learning styles, and the next one to the effects of computer assisted instruction on students with different personality types.

Sensing, and Intuitive Students

Hoffman, and Betkouski (1981) report a series of research results on personality and learning abilities of students. The MBTI scale most studied has been that of the Sensing [S] and Intuitive [N] functions. They point out that "the S–N [Sensing–Intuitive] scale of the MBTI is a very useful and unusual one since it gives information about both ability and attitude, using only self-report questions" (p. 15). These authors also observed that some studies have examined relationships between student type and academic performance reporting that higher scores are consistently found on the Intuitive [N] side of the scale.

Table 10 shows the relative frequency of Sensing and Intuitive types at different levels of scholastic achievement as reported by Hoffman, and Betkouski.
Table 10. Relative Frequency of Sensing and Intuitive Types at Different Levels of Scholastic Achievement

<table>
<thead>
<tr>
<th>Level of Achievement</th>
<th>Sensing</th>
<th>Intuitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>671 Finalists for National Merit scholarships</td>
<td>17%</td>
<td>83%</td>
</tr>
<tr>
<td>3676 Freshman at Ivy League colleges</td>
<td>41%</td>
<td>59%</td>
</tr>
<tr>
<td>3503 Academic 11th and 12th graders, Pa. high schools</td>
<td>58%</td>
<td>42%</td>
</tr>
<tr>
<td>1430 Non-academic 11th and 12th graders, Pa. high schools</td>
<td>85%</td>
<td>15%</td>
</tr>
<tr>
<td>500 Adults who did not finish 8th grade</td>
<td>99.6%</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

It has also been observed that interest in science and science achievement is closely connected to the Intuitive [N] preference. Another important result directly related to the present study is that though there is no significant difference between the attitudes of the Sensing or Intuitive students toward mathematics, the N students, as a group, outperform the S students on mathematics achievement.

Sensing [S] types favor extrinsic motivation, that is, response and its reinforcement, while Intuitives [N] favor intrinsic motivation, that is, stimulus novelty and its exploration. Hoffman, and Betkouski's interpretation of S–N differences suggest that these differences "are related to varying interests and not necessarily a superiority of ability of one type over another" (p. 18).
They also note that current teaching practices in school systems favor Intuitive students.

Those students who prefer perception through sensing become aware of things directly through their five senses; they are interested in actuality around them. In contrast, those students with a preference for the intuitive process rely upon ideas and association that the unconscious tacks onto perceptions coming from the outside; these students are more interested in the possibilities suggested by incoming data, rather than the data themselves.

Intuitives therefore appear to have the greater potential for success in school from the beginning. Most classroom instruction is based on the use of symbols, an area in which intuitives show up well. Sensing students however, are clearly in the majority. Progress has been made in coming up with curricula which serve a variety of interests; we need to look more closely at instructional methodology which gives all students an equal chance at success in the classroom. (p. 18)

Some authors suggest the design of curricular activities for elementary school that allow children to develop their Intuitive function. Students will improve in mathematics and science
classes as a natural consequence (DiTiberio, 1983; McCaulley, 1977; Natter, 1976).

**Student Personality Type and Computer Assisted Instruction**

This section reports the results of three studies that try to determine how a computer environment based on a behaviorist approach to teaching like that defined by Computer Assisted Instruction (CAI) may affect attitudes, preferences, and achievement of students with different personality types.

**Personality types and structure.** Smith (1971) studied computer-assisted-instruction decision making related to learner characteristics. The study tried to determine attitudes, preferences, and knowledge of students with different personality types, as determined by the MBTI, when instructional materials with different amounts of structure were used. Four methods of presentation were prepared and students were randomly assigned to one of these presentations. The presentations ranged from the highly structured, where all instructional decisions were made by the computer (the author calls this presentation "didactic"), to the situation where students had to agree to receive each module and could determine their own sequence (this presentation is referred to as "laissez-faire").

The population consisted of undergraduate education majors in four science methods classes at The Ohio State University. Smith worked with 250 students; the sample size was limited by the
number of terminals and ports that were available for the students to use and by the availability of the audiotape and slide facilities. The mode of CAI was via an IBM 2741 teletype computer terminal utilizing the Coursewriter III language. The topic of the CAI was limited to the recognition and use of behavioral objectives. The personality characteristics were limited to the Extrovert–Introvert and Sensing–Intuitive scales of the Myers–Briggs Personality Type Indicator.

Some of the findings related to the present study were that: (1) Extroverts seemed to prefer to make their instructional decisions whereas the introverts seemed to prefer someone else to make the decisions, (2) Sensing students had the most positive attitude toward CAI and toward behaviorally stated and educationally unimportant objectives, (3) There appeared to be a trend for Sensing students to have a more positive attitude with less structure whereas Intuitive students preferred structure, (4) Students with the combination of Introvert and Sensing personality traits had a significantly more positive attitude toward CAI and the program than did Extrovert–Sensing students.

**Personality types and learning decisions.** White, and Smith (1974) report the results of an experiment designed to identify the differential effects of the degree of student responsibility for learning decisions with different personality types. The Myers–Briggs Type Indicator Form E was administered to over 200 teacher
education students from secondary science, elementary science, and health education method classes. The personality profile of each student was determined for the Extrovert–Introvert \( [E-I] \) and the Sensing–Intuitive \( [S-N] \) scales. The authors developed an instructional program consisting of computer assisted instruction and a series of four audio-visual activities. The CAI modules for this course were designed to provide highly individualized experiences for the students.

These authors found that: (1) As the responsibility for the selection of learning activities was shifted to the students, N type students became less satisfied and S type students became more satisfied with CAI as a means of instruction; this positive attitude was stronger for the Sensing–Introvert type than the Sensing–Extrovert type; (2) The Sensing type students had a more favorable attitude toward the use of behavioral objectives for instructional planning than did the Intuitive [N] types; (3) The Sensing type students showed a lower preference for the behaviorally stated educationally unimportant objectives than the Intuitive [N] types; (4) Both the extrovert and the introvert types tended to perform more error-free when they followed a carefully prescribed learning sequence. Apparently Extrovert students had a stronger tendency than the Introvert to follow the "prescribed" pattern.
Figure 7 shows the interaction of Intuitive-Sensing and Extrovert-Introvert on attitude toward CAI (taken from White, and Smith, 1974, p. 20).

![Diagram showing the interaction of Intuitive-Sensing and Extrovert-Introvert on attitude toward CAI.]

**Figure 7. Interaction of Intuitive-Sensing and Extrovert-Introvert Scales and Attitude Toward CAI**

This interaction shows that Sensing-Introvert [SI] types have more positive attitude toward CAI than Intuitive-Extrovert [NE], Intuitive-Introvert [NI], and Sensing-Extrovert [SE] types. SE types are the students who displayed a very low attitude toward CAI.

**Personality types and CAI dropouts.** Hoffman, Waters, and Berry (1981) carried out a study with 3, 500 students at the Naval Training Center, Pansacola, FL. The purpose of this study was to see if any significant relationships existed among personality types and student performance in a self-paced computer-assisted
instructional program. They found that there was a high correlation between student dropouts and certain personality types as defined by the MBTI. Sensing types tended to complete the computer assisted portion of the program much sooner than the Intuitive types, and generally, the Extrovert-Perceiving [EP] types overwhelmingly tended to drop out of the CAI program. These authors suggest that CAI favors introvert students:

Learning by means of a computer assisted instruction program would seem to favor those who have the ability to quietly concentrate, are able to pay attention to details, have affinity for memorizing facts and can stay with a single task until completion. . . . Where it was found that those with primarily Sensing perceptions tend to do well, it was also found that those with the Extrovert, Intuitive, and Perceiving (EN-P) combination were highly likely to drop out of the instructional program. (p. 83)

The results of the studies described in this section reveal that computer environments designed with a behaviorist approach favor students who are Introverted and who prefer the Sensing function [IS].
Estimated Frequencies of the MBTI Types

Myers, and McCaulley (1985) report frequencies of MBTI types in the United States population. They observed that the majority of Americans have an extrovert attitude and prefer the Sensing function, and more than half the population prefers Judging over Perceiving. Their estimates suggest that 60% of males in the United States are ESTJ and that 65% of females are ESFJ type. In this respect, McCaulley, MacDaid, and Kainz (1985) point out that:

It is clear that we cannot yet answer precisely questions about the distribution of types in the population. However, the tables enable a counselor to confirm to an INFJ that it is indeed hard for him or her to find kindred spirits—there are not many of them. The tables can show Sj [Sensing-Judging] types that although they are in the majority, there are many people "out there" who may not share their views. (p. 8)

From these percentages, and the results of the studies reported in previous sections (see Table 10), it could be concluded that traditional classes favor a small percentage of students who are Intuitive [N] types; and that CAI does little to help those students whose personality types are predominant in the general population, namely ESTJs and ESFJs. Another question arises here—Can new software be designed to provide computer
environments that give all students an equal chance at success in the classroom?

Summary of the Literature Review

The results of the MBTI studies reported in this chapter focused on relationships between the variable personality type and other variables such as occupation, teaching styles, or learning styles conform an interesting spectrum of factors that can be used to characterize school mathematics teachers, and the impact of CAI in education. In the following, some of the MBTI studies results will be listed: (a) in schools, the most common MBTI type of teacher is ESFJ, (b) school mathematics teachers are predominately ESTJ, (c) the preferred methods of teaching of ESTJ teachers include: recitation, drill, composition, test/quizzes, and demonstration, (d) a large number of Sensing students who are in preparation for teaching have Intuitive teachers who may not appreciate Sensing characteristics, (e) CAI instruction favors Introvert–Sensing [IS] students, (f) Extrovert–Sensing [ES] students, and Intuitive [N] students are likely to drop out a computer environment designed with a drill-and-practice approach.

Research Questions

The literature review suggests considering personality type as a factor influential in secondary mathematics teachers selection and uses of geometry software. Personality type, selection of geometry
software, and use of geometry software were the original categories that the present study included (see Figure 8).

**Figure 8. Core Category, and Subcategories**

These categories were later divided into subcategories to explore in more detail whether the use of computers and geometry software whose design is not based on a drill-and-practice approach to teaching was related to a pattern of teaching, or conversely, whether preferred methods of teaching related to a pattern of uses of computers in education. This subcategorization later facilitated the coding process of participants' computer environment designs and interviews. Chapter 3 describes these subcategories and the way they were used in the study. The research questions that were set at the beginning of the study are listed below:
• What are the preferred Jungian psychological functions and attitudes of participating secondary mathematics preservice teachers?

• Is there a difference between observed patterns of teaching strategies and evaluation methods in regular classrooms, with no use of computers, and the preferred teaching strategies and evaluation methods of participating preservice secondary mathematics teachers when they plan to use computers and the software Geometric Supposer and Geometer's Sketchpad in their high school geometry classes?

• Do Intuitive [N] and Sensing [S] types of teachers differ in their use of computers and of geometry software?

The objective of the whole analysis was twofold: (1) To observe whether different MBTI types of teachers were found planning to use computers in their high school geometry teaching in different ways, and (2) To observe whether Intuitive [N] teachers and Sensing [S] teachers differ in the way they plan to use computers in their classrooms and in the way they plan to use their preferred geometry software.

The whole investigation was based on the ideal of the computer setting of participating preservice teachers. The hypothetical context of the study was that teachers and students had access to
technology in schools, that computers and any type of software were available to all students, and that teachers just had to concentrate on designing a computer environment that facilitated high school geometry. Chapter 3 describes the procedures followed to explore the participating preservice secondary mathematics teachers' preferred teaching strategies, evaluation methods, and computer environments to teach high school geometry with the Geometric Supposer and/or the Geometer's Sketchpad.
CHAPTER III
DESIGN OF THE STUDY

The first chapter discussed the need for exploring the role that teachers plan to play in computer environments. In light of the literature review that reports the results of MBTI studies that characterize the methods of teaching of school teachers and school mathematics teachers, personality type was identified as a core category to explore how preservice teachers plan to adapt their preferred teaching styles to a computer environment. This chapter describes the methodology and procedures that were followed to investigate patterns of preferred teaching strategies and evaluation methods related to the use of the Geometric Supposer and/or the Geometer's Sketchpad.

According to Glesne, and Peshkin (1992), "qualitative inquiry is an umbrella term for various philosophical orientations to interpretive research" (p. 9). There are different methodologies, based on different assumptions and focuses, to carry out qualitative research. As it was mentioned before, at the beginning of Chapter 2, the methodology used in the present study was taken from Glaser, and Strauss (1967). This methodology is based on comparative analysis, and theoretical sampling.
Comparative analysis is a "strategy that involves the systematic choice and study of several comparison groups" (p. 9). This strategy was convenient to compare the four teachers whose methods of teaching will be described in Chapter 4. Glaser, and Strauss (1967) point out that "comparative analysis is a general method, just as are the experimental and statistical methods . . . Furthermore, comparative analysis can, like those other methods, be used for social units of any size" (p. 21).

Theoretical sampling is the process of data collection whereby the researcher "jointly collects, codes, and analyzes his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges" (p. 45).

According to Glesne, and Peshkin (1992), "the use of multiple-data-collection methods contributes to the trustworthiness of the data" (p. 24). To satisfy this requirement, four different methods of data collection were used. Patton (1980) describes three types of triangulation used in qualitative research to validate and verify the data analysis. Two types of triangulation were carried out for validation and verification purposes which are described later in this chapter as well as the types of data that were collected, the setting and subjects, and the instrumentation and conditions of data collection.
Setting and Subjects

A Geometry Software Workshop (GSW) was designed to collect data for the present study which included seven sessions that will be described in the procedures section. By the end of the first month of Fall semester, the teacher of a Methods of Teaching Secondary School Mathematics course at a large midwestern university presented the GSW as an option to get seven hours towards the field experience component of the course (the usual procedure to fulfill the field experience requirements is tutoring high school students). A handout with the schedule of the workshop and a form where interested students could sign was passed out to the 28 students in the class (see Appendix E). Twenty students turned the signed form in. All 20 attended the software demonstration but just 19 completed all the activities.

The process of gathering data started September 24 and ended December 8 of 1993. The software demonstration was carried out in a computer laboratory with enough computers so that each student could work on a computer.

Instrumentation and Conditions of Testing

Four different data-gathering methods were used: (1) The Myers-Briggs Type Indicator was used to determine the preferred Jungian psychological functions of participating preservice teachers, (2) The geometry activities provided information about the way preservice teachers plan to use computers in education; (3)
The interviews reflected the reasons behind preservice teachers' selections; (4) The geometry software evaluation was designed to observe whether there was a relationship between some preferred functions (in particular, S and N) or attitudes (in particular, E and I) and willing to know more about the use of computers in mathematics education.

The Myers–Briggs Type Indicator (MBTI)

The main instrument used in the study was the Myers–Briggs Type Indicator (MBTI) which measures personality characteristics in terms of psychological types as originally defined by Carl Jung (1971) and expanded by Isabel Myers. The form G of the instrument consists of 94 two-choice items. It requires between twenty and thirty minutes to complete (see Appendix F).

The Intuitive-Sensing and Extrovert-Introvert scales were used as subcategories of personality type to explore patterns of teaching strategies and evaluation procedures when planning to teach high school geometry with computers. The MBTI scores were used to determine participants’ preferences for one of the two following functions: Intuitive [N] or Sensing [S]. And one of the two attitudes: Extrovert [E] or Introvert [I]. Myers, and McCulley report the reliability that was gotten for these two scales—Intuitive-Sensing [N-S] and Extrovert-Introvert [E-I]—by two methods: split half and test re-test. The split-half reliability, for the form G, reported for the N-S and E-I scales are .84 and .82
respectively. The test-retest reliability reported for the N–S scale is .84 and for the E–I scale is .79. Chapter 2 describes the indicator and includes a discussion about its validity. Appendix C contains the reliability indices reported for each of the scales of the indicator.

The Geometry Activity

Another source for gathering data was the geometry activity. This assignment included the design of: (a) a computer environment, (b) a geometry activity, and (c) a form to evaluate students' understanding. Participants followed the format of the geometry scenarios created by inservice high school teachers members of the Geometry Project of St. Olaf College, Minnesota (See Appendix G). The possibility of combining the two software—Geometric Supposer and Geometer's Sketchpad—was open. One week was left for this part of the workshop, though it was specified that participating preservice teachers had to work at least three hours on the design of the computer environment and the geometry activity.

For the design of the computer environment, preservice teachers had to choose one or more items from each of the categories presented in Figure 9. The idea of asking students to design a geometry activity and a computer environment was to allow exploration of reasons behind the decisions made in planning a class to be taught with geometry software. The
geometry activity included three sections. In the first section preservice teachers had to design a computer environment and give a rationale; the second section included the activity itself; and in the third one they had to describe procedures for evaluating their students' understanding of the concept, or the geometrical relationship presented in the activity (Appendix H contains a copy of this handout).

<table>
<thead>
<tr>
<th>Technology:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry Software</td>
<td>Geometric Supposer</td>
</tr>
<tr>
<td>Overhead projector</td>
<td></td>
</tr>
<tr>
<td>Paper and pencil</td>
<td>Geometer's Sketchpad</td>
</tr>
<tr>
<td>Geometry instruments</td>
<td></td>
</tr>
<tr>
<td>Folding paper</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Topic:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Triangles</td>
<td></td>
</tr>
<tr>
<td>Quadrilaterals</td>
<td></td>
</tr>
<tr>
<td>Circles</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Van Hiele Levels:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td></td>
</tr>
<tr>
<td>Level 3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Setting:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>One computer</td>
<td></td>
</tr>
<tr>
<td>Computer Lab.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How will students work?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperatively</td>
<td>Emphasis on discussion</td>
</tr>
<tr>
<td>Groups</td>
<td>Emphasis on dividing the task</td>
</tr>
<tr>
<td>Individually</td>
<td>Emphasis on analysis</td>
</tr>
<tr>
<td>Teams</td>
<td>Emphasis on drill and practice</td>
</tr>
<tr>
<td>Whole class</td>
<td>Emphasis on competition</td>
</tr>
</tbody>
</table>

**Figure 9.** Characteristics of Planned Use of Geometry Software
The Interview

Patton (1980) suggests the *standardize open-ended interview* when "it is important to minimize variation in the questions posed to interviewees. This reduces the possibility of bias that comes from having different interviews for different people" (p. 198). He says that interviews that relies entirely on the spontaneous generation of questions increase the problem of "obtaining more comprehensive data from certain persons while getting less systematic information from others" (p. 198). Although the standardize open-ended interview allows to obtain "data that are systematic and thorough for each respondent" (p. 198) it reduces flexibility and spontaneity. This type of interview was selected to facilitate comparison among groups.

The first interview protocol was based on the nineteen computer environments described in the geometry activities that were turned in. The first four interviews were used to improve the original protocol. The same protocol was used with the other 15 cases. All the interviews were carried out in the same setting, an office in the Education building. The duration of the interviews was between 20 and 30 minutes. All the interviews were audiotape recorded. After reviewing the geometry activities and the transcripts of the nineteen interviews, four cases were selected to focus the study and to illustrate the discussion presented in
Chapter 4. The four cases selection procedures are described later in this chapter.

The Geometry Software Workshop Evaluation

The fourth kind of data collected was the evaluation of the Geometry Software Workshop. Since the participation in the workshop counted seven hours towards field experience, it was not clear whether students participated in the workshop because they were interested in the use of computers in education or whether they were interested in the credit hours.

The form to evaluate the geometry software workshop consisted of two parts. The first one asked the student whether he or she would be interested in receiving information about the use of technology in mathematics education or participating in other workshops. The second part consisted of five items requiring students' opinions about the usefulness of the demonstration of the software, the booklets designed for the workshop, the activities presented during the demonstration, and how students thought the workshop could be improved (see Appendix I).

Procedures

Participating preservice secondary mathematics teachers had to: (1) Read a section of a book (Chazan, and Houde, 1989) on the uses of computers in teaching geometry; (2) Take the MBTI test\(^1\).

\(^1\) A handout with a description of the 16 types (Appendix B) was given to them.
(3) attend three sessions of geometry software demonstration (Appendix E); (4) Select a geometry topic among the three included in the workshop—triangles, quadrilaterals, circles; (5) Design a geometry activity (Appendix H); and (6) Discuss the geometry activity with the instructor of the workshop. Table 11 shows the time allocated to each of the activities.

**Table 11. The Geometry Software Workshop**

<table>
<thead>
<tr>
<th>Session</th>
<th>Activity</th>
<th>Time in minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reading of an article on the use of computers in geometry teaching.</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Taking the MBTI test.</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>Triangles with the Geometric Supposer and with the Geometer's Sketchpad.</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>Quadrilaterals with the Geometric Supposer and with the Geometer's Sketchpad.</td>
<td>60</td>
</tr>
<tr>
<td>5</td>
<td>Circles with the Geometric Supposer and with the Geometer's Sketchpad.</td>
<td>60</td>
</tr>
<tr>
<td>6</td>
<td>Design of the geometry activity.</td>
<td>180</td>
</tr>
<tr>
<td>7</td>
<td>Interview.</td>
<td>30</td>
</tr>
</tbody>
</table>
The Reading

Chazan, and Houde (1989) argue against that prevalent image that majority of people may have about the computer user. They say that any body can learn to use computers and they explain how teachers can use them to help their students to develop conjectures about geometrical relationships. They present this discussion in the section titled "Arguments Against some Commonly Accepted Myths" of their book How to Use Conjecturing and Microcomputers to Teach Geometry. A copy of this section was distributed after the presentation of the Geometry Software Workshop. The reading was optional.

The Administration of the Myers–Briggs Type Indicator

It takes around 20 to 30 minutes to answer and scored the MBTI. The MBTI was administered at 8:30 a.m., half hour before the methods class. The form G is self scorable so participants got their personality type. At the time they turned the indicator in, a copy of two tables was handed out: The description of sixteen types taken from Myers, and McCaulley (1985) and the Silver, and Hanson's (1985) characterization of teachers. Chapter 4 describes the MBTI types attracted by the workshop.

Geometry Software Demonstration

The original group split into two groups for the software demonstration. Sessions 3, 4, and 5 that included the software demonstration were given twice a week, on Monday and on
Wednesday from 7:00 to 8:00 p.m. Students selected the day to their convenience. Theses sessions were carried out in a computer laboratory with 20 Macintosh IIsi. The laboratory was equipped with computer screen projection panel. The Geometer's Sketchpad was in the network and students had access to that software in all the computers in the laboratory at any time. However, the version of the Geometric Supposer that was used in the study was for the Apple II. The Department of Mathematics Education provided an Apple to be available in the laboratory during the three sessions in which the software of the Geometric Supposer was going to be presented. The first half hour was devoted to the demonstration of the Geometric Supposer and the second half hour to the Geometer's Sketchpad. The scenarios were different for each software; therefore, the software demonstration was different too, that is, two settings were used, one computer for the whole class (with the Geometric Supposer) and one computer for each student (with the Geometer's Sketchpad).

**One computer for the whole class.** A booklet with three computer laboratories was passed out each session. Each booklet contained activities at level 0, level 1, and level 2 of the original van Hiele model (van Hiele, 1986; and Fuys, Geddes, and Tischler, 1988). See Appendix J for a summary of the van Hiele model of geometric thought that was given to preservice teachers. The problems of the day to be solved by the whole class were projected
on one side of the board with an overhead projector. On the other side of the board the computer screen was projected. The instructor of the workshop was operating the computer trying out the strategies that were suggested by preservice teachers to solve the problems.

**One computer for each student.** The computer laboratories included in the booklets that were designed for the workshop contained three sections: (a) procedure listing the commands needed to draw the figures and to explore the relationships and/or the measurement that the activity required, (b) the geometry activity, and (c) the worksheet. Appendix K contains copies of two laboratories one for the Geometric Supposer and other for the Geometer's Sketchpad. Each student worked by himself or herself on one computer, though they were allowed to talk to each other and to exchange ideas. There was never enough time to complete the three activities of the booklet.

**The Interview**

Interviews were carried out a week after the Geometry Software Workshop (GSW) to observe what were the preferences of participants on the following aspects considered in the design of the computer environment: (a) technology, (b) geometry content, (c) van Hiele level, (d) setting, and (e) classroom interactions.

All the interviews were conducted in a Curriculum and Instruction Department room. The first five minutes of the
interview were devoted to explain the purpose of the study and the need for getting their personal point of view about the use of computers in education. Figure 10 contains the categories that were used to explore patterns of computer uses and preferred teaching strategies and evaluation procedures.

![Diagram](image)

**Figure 10.** *Elements to be Incorporated in a Computer Environment to Explore Geometrical Relationships*

First Protocol. The rationale that student teachers wrote for selecting the categories they selected for the design of their computer environment was used to develop the first protocol for the interview. This first protocol was used the first day of the interview with four participants. These interviews were reviewed
and used to improve the original protocol. The items included in the first protocol are listed below.

- Why did you choose this topic?
- Why do you think is important to teach this concept?
- Why do you think this activity corresponds to that van Hiele Level (0, 1 or 2)?
- Why did you choose this software?
- Did you plan this activity to be taught with one computer for the whole class or to be taught in a computer lab where each student will have access to a computer?
- What do you think will work better, cooperative learning or individual learning?
- Do you think students will learn more if they explore the concept by themselves or if they work in groups?

The second protocol. After analyzing the four interviews carried out the first day of the week devoted to the interviews (see Appendix E), it was observed the need of including more items to the protocol and to write a protocol to be used with the rest of the participants, so their responses could be compared. Figure 11 lists the items included in the refined protocol.
1. How many courses have you taken where the Geometer's Sketchpad is used?

2. Why do you prefer to work with the Geometer's Sketchpad? What are the characteristics that you like more?

3. Do you think you can use the Geometer's Sketchpad to teach all high school geometry? Even geometry proofs? How would you use the Geometer's Sketchpad to teach geometry proofs?

4. Why did you choose this topic and this concept?

5. Why did you set your activity at level ____?

6. Why do you prefer your students work in a laboratory?

7. Why do you want your students work individually [or in groups]?

8. Picture yourself in front of your class. How are you going to present this activity?

9. How are you going to evaluate understanding?

10. In terms of teacher education: What do you think could help preservice mathematics teachers to get ready to teach mathematics classes with the aid of computers?

11. Do you think that programming courses would help preservice teachers to feel more comfortable?

12. Going back to your activity presentation¹:

   a) What is going to be the role of the teacher?
   
   b) What is going to be the role of computers?
   
   c) When cooperative learning could be useful?

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¹The context created for these items was the use of computers during the school year, not just for the presentation of the geometry activity.
Rapport. The investigator met with the teacher of the methods class for a month, once or twice a week, to plan when and where the data gathering was going to take place. Involving the teacher in this process allowed establishing a professional relationship with him, let him know the content and objective of the workshop, gaining his interest in the study—he realized that his students would learn two interesting pieces of software: the Geometric Supposer and the Geometer's Sketchpad. The teacher presented the workshop and he strongly recommended "taking the opportunity to learn two powerful pieces of software." The role of the teacher was very important for recruiting preservice secondary mathematics teachers. The seven credit hours that preservice teachers could get participating in the workshop made it even more attractive to them.

The activities carried out prior to the interviews worked like ice breaking. The workshop was conducted outside the methods class period of time. During the workshop the pedagogical elements to be incorporated in a computer environment were discussed while preservice teachers explored and discovered new geometrical relationships. The workshop was carried out in a computer laboratory. Fifteen minutes of the session or so were devoted to showing different ways of using the computer in educational settings (one computer for the whole class or one computer for each student). For the rest of the class, students worked on the
booklet activities. The investigator created a very relaxing environment where participating teachers were given a task that always ended in establishing a conjecture of some geometrical relationships and they had to explore ways to validate them.

The workshop allowed this investigator to communicate why it was important to think of the design of computer environments and to show them examples of computer environments developed by inservice teachers (Appendix G describes the Geometry Project and lists the scenarios that the Geometry Project high school inservice teachers developed for the Geometric Supposer and the Geometer's Sketchpad). Participating preservice teachers had to select those computer environment characteristics they thought would facilitate the learning of high school geometry.

The interview was carried out in a very comfortable and quiet place. The relaxing atmosphere was conducive to making the preservice teachers comfortable. Almost all of them expressed freely their point of view about how they would use the geometry software they had selected for designing their computer environment (their preferred teaching strategies, classroom interactions, evaluation methods, and also they had a clear image of the teacher's role when teaching mathematics with computer software) with exception of a very introverted student who was quite nervous during the interview. She gave very short answers and it was not possible to determine her opinion about the use of
computers in education. Some of the student teachers described how they were frightened at the time they started college because they did not know how to use computers. They said they were afraid of having to teach mathematics with computers because they thought they did not have enough experience working with computers in college either.

**Geometry Software Workshop Evaluation**

All the students turned in two copies of their geometry activity, one hard copy and a copy on a floppy disk. There were files for both types of hardware, the Macintosh and the IBM. Two files were created, one containing all the IBM activities and the translations of the activities written on a Macintosh; the other, the Macintosh activities and the translations of the IBM activities. (The name of the author of each activity had been erased before creating the files). The floppy disks were given back to participants containing a copy of the 19 activities at the beginning of a methods class. The evaluation form was given the same day the floppy diskettes of participants were given back.

Since the workshop provided 7 hours (out of 20) towards field experience, it was not clear whether students participated in the workshop because they were interested in the use of computer in education or whether they were interested in the credit hours so the workshop evaluation included two items asking for participation in: (a) a workshop the following summer, (b) other
coming workshops on the use of technologies in mathematics education. Appendix I contains copies of the evaluation forms and the results are summarized in Chapter 4.

Selection of Four Cases

Theoretical sampling was used throughout the study and it was particularly useful in the selection of the four cases. Glaser, and Strauss (1967) describe theoretical sampling as "the process of data collection for generating theory whereby the analyst jointly collects, codes, and analyzes his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges" (p. 45). The intention of this investigator was not to generate theory but to develop a conjecture about the plausible ways of integrating the use of computers in the teaching of high school geometry.

According to Glaser, and Strauss, the basic criterion governing the selection of comparison groups is their theoretical relevance for the development of emerging categories. They suggest to "select dissimilar, substantive groups from the larger class . . . compar[e] groups that seem to be non-comparable on the substantive level, but that on the formal level are conceptually comparable" (p. 54).

The geometry activities and the interviews were used to select the four cases reported in these notes. First, the rationale for selecting the components of the computer environment and the explicitness of the role of the teacher and students to carry out the
geometry activity were used to select eight possible cases. The second criterion was based on the results of the interviews, that is, whether the preservice teacher expressed himself (or herself) as a student or as a teacher. If the preservice teacher's reasons for selecting the topic, the van Hiele level, the setting, and so on, were focused on what would help the students understand, what they would like, or what would be motivating, then it was considered that the preservice teacher was thinking as a teacher at the time he or she was working on the design of the geometry activity. Chapter 4 describes the characterization of the four selected cases.

Once the four cases were selected, the geometry activities and the interview transcripts were reviewed. The differences among the four cases were not apparent, so the answers of the four cases to each item of the modified interview protocol (see Figure 11) were put together and compared. The patterns did not appear at this stage either. Then the analysis was focused just on the interview items that could be related to preferred teaching styles, method of teaching, and computer uses. These items were: 6, 7, 8, 9, 12a, 12b, 12c. The answers of the four cases to each of the seven items were compared. Some differences were observed. Finally, the paragraph sections illustrating the preferred teaching styles, evaluation methods, and computer uses were identified.
At this point this investigator discovered some similarities between the four selected cases and the Silver, and Hanson's (1985) characterization of the four MBTI types of teachers.

**Triangulation**

The verification and validation of the data analysis carried out in the present study was based on two types of triangulation: (1) reconciling qualitative and quantitative data, and (2) multiple perspectives from multiple observers (Patton, 1980). After this investigator had carried out the categorization of the four selected teachers' responses, the results were compared with those given by Silver, and Hanson (1985). The two characterizations were quite similar. The possibility of being influenced by previous readings on MBTI characterizations of school teachers was considered. Therefore it was necessary to involve an external researcher to categorize the four selected teachers' responses to the interview items being reported in this chapter.

Appendix L describes in detail the procedures followed to involve the external researcher in the study. This triangulation was based on the seven interview items that were used in the data analysis. The descriptors used by Silver, and Hanson (1985) to categorize the preferred teaching strategies, teaching styles, and evaluation methods of the four MBTI types of teachers were provided to the researcher including few more that this investigator included in her categorization. The descriptors used to categorize
the preferred computer uses were taken from the subcategories that were included in the guidelines for the design of the computer environment given to participants. Chapter 4 contains the results of the data analysis.

Summary of Chronology of Procedures

The study was reviewed and approved by two Human Subjects Committees, one from The Ohio State University, the academic home of the researcher, and the other, from the Indiana University-Bloomington, where the study was conducted (Appendix M contains a copy of the letters of approval from the office of Human Subjects of both universities). Data were gathered in four different locations with five different methods: (a) participants took the form G of the MBTI in a classroom that was assigned for that purpose, (b) During the workshop student teachers were observed whereas working with the computers; (c) a geometry activity that included the design of a computer environment, an activity to be carried out with a geometry software, and a worksheet was collected one week after the demonstration of geometry software, (d) a half-hour interview was carried out with each of the participating preservice teachers to discuss their geometry activity, (e) a questionnaire to evaluate the workshop was given one month after the interviews were carries out.

Almost all data were analyzed immediately after the gathering with exception of the interviews that were first transcribed by a
person who was hired for that purpose. The transcripts were reviewed listening to the tapes, a month after the interviews were carried out. The coding and classification of the data took most of the time of the data analysis. The interviews that were selected to be reported in these notes were first coded and categorized by the author of these notes. Once the categories had been determined, the responses to selected items of the modified protocol were also categorized by an external researcher with experience in qualitative research. Field notes were taken since the first meeting with the teacher of the methods class.
CHAPTER IV

ANALYSIS OF DATA

It appears that teachers' natural inclinations for certain classroom climates, for expression of affect and for control of student behaviors—all of which have a potential bearing on teacher effectiveness with students—can be usefully studied in the patterns provided by the MBTI. (DeNovellis, and Lawrence, 1983, p. 45).

The Jungian functions, as conceptualized by Katharine Briggs and Isabel Myers, have been used to characterize teachers and their preferred teaching strategies and evaluation procedures. Chapter 2 includes three characterizations of schoolteachers—Keirsey, and Bates (1978), Myers, and McCaulley (1985), and Silver, and Hanson (1985)—these characterizations are based on class observations of teachers in regular classrooms with no use of computers and identify four types of teachers.

One of the objectives of the present study was, first, identify the four types of MBTI teachers and to observe their preferred teaching styles, and evaluation methods to see whether there was a difference between the MBTI previous schoolteacher's characterizations and the observed patterns of participating
teachers’ preferences when they planned to incorporate the use of computers in the education process.

The content of this chapter has been organized in four sections. The first three sections provide the data analysis that was carried out to answer each of the three research questions that were stated in Chapter 2 and which are listed again below. The last section presents the conclusions of the data analysis.

The research questions to be answered in this chapter are as follows:

- What are the preferred Jungian psychological functions and attitudes of participating secondary mathematics preservice teachers?
- Is there a difference between observed patterns of teaching strategies and evaluation methods in regular classrooms, with no use of computers, and the preferred teaching strategies and evaluation methods of participating preservice secondary mathematics teachers when they plan to use computers and the software Geometric Supposer and Geometer’s Sketchpad in their high school geometry classes?
- Do Intuitive [N] and Sensing [S] types of teachers differ in their planned use of computers and of geometry software?
The MBTI scores were used to answer the first research question. To answer the second and third research questions, the computer environment, the geometry activity, the worksheet, and responses to seven selected items of the refined interview protocol of four selected participants were used. The study assumes that preservice teachers' geometry activities and their interview responses reflect their perception of the role that computers should play in high school geometry teaching as well as ways of integrating this technology into their everyday classes. A summary of the data analysis carried out to answer the research questions of the study is presented in what follows.

Research Question 1

What are the Preferred Jungian Psychological Functions and Attitudes of Participating Secondary Mathematics Preservice Teachers?

Based on theoretical sampling (this procedure is explained in Chapter 3), this study focuses on comparing Sensing [S] with Intuitive [N] types, and Extrovert [E] with Introvert [I] types. This section reports the MBTI personality types of participating preservice secondary mathematics teachers, and the configuration of the Monday and Wednesday sections of the Geometry Software Workshop after participants self-selected one of the two sections, and how this configuration affected the classroom environment.

The Geometry Software Workshop attracted the attention of nine MBTI types which allowed a good margin for selecting the four
cases reported in these notes which will represent the four MBTI types of teachers. The data gathered on the nineteen cases provided a reference that mediated the analysis carried out on the four selected cases and the conclusions based on this analysis.

Twenty preservice teachers attended the demonstration of the Geometric Supposer and the Geometer’s Sketchpad but only 19 completed the geometry activity and the interview.

Proportion of Intuitive and Sensing Types in the Geometry Software Workshop

Table 12 shows the preferred psychological functions and attitudes of 20 secondary mathematics preservice teachers as measured by the Myers–Briggs Type Indicator (see Chapter 2 for a description of the Indicator, and Appendix B for a description of the psychological types). Table 13 shows that 15 Sensing [S] and 5 Intuitive [N] preservice teachers participated in the study. This result, fewer N types than S types, was expected as reported by several authors. For instance, Myers, and McCaulley (1985) estimate that 75 percent of the U.S.A. population is comprised by Sensing types. Keirsey and Bates (1978) point out that 75 percent of the students in a regular school classroom are Sensing types.
Table 12. Preferred Psychological Functions of Participating Preservice Teachers

<table>
<thead>
<tr>
<th>Preferred Personality Type</th>
<th>JUNG'S PSYCHOLOGICAL FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E</td>
</tr>
<tr>
<td>1. ISFJ</td>
<td>11</td>
</tr>
<tr>
<td>2. ISTJ</td>
<td>2</td>
</tr>
<tr>
<td>3. ISFJ</td>
<td>4</td>
</tr>
<tr>
<td>4. ISTJ</td>
<td>12</td>
</tr>
<tr>
<td>5. ESFJ</td>
<td>21</td>
</tr>
<tr>
<td>6. ENFP*</td>
<td>20</td>
</tr>
<tr>
<td>7. INFP*</td>
<td>8</td>
</tr>
<tr>
<td>8. ISTJ*</td>
<td>10</td>
</tr>
<tr>
<td>9. ESFJ</td>
<td>15</td>
</tr>
<tr>
<td>10. ESTJ</td>
<td>17</td>
</tr>
<tr>
<td>11. ESFJ</td>
<td>15</td>
</tr>
<tr>
<td>12. ISTJ</td>
<td>5</td>
</tr>
<tr>
<td>13. ENFP</td>
<td>24</td>
</tr>
<tr>
<td>14. ENFJ</td>
<td>22</td>
</tr>
<tr>
<td>15. ISTJ</td>
<td>11</td>
</tr>
<tr>
<td>16. ESTJ</td>
<td>17</td>
</tr>
<tr>
<td>17. ISFP*</td>
<td>6</td>
</tr>
<tr>
<td>18. ESTJ</td>
<td>20</td>
</tr>
<tr>
<td>19. INFN</td>
<td>12</td>
</tr>
<tr>
<td>20. ESFJ</td>
<td>22</td>
</tr>
</tbody>
</table>

*Four selected cases on whose data was focused the analysis and discussion of results.
Table 13. Frequency of Introvert and Extrovert Preservice Teachers

Enrolled in the Geometry Software Workshop

<table>
<thead>
<tr>
<th></th>
<th>Sensing [S]</th>
<th>Intuitives [N]</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introverts</td>
<td>n = 8</td>
<td>n = 2</td>
<td>n = 10</td>
</tr>
<tr>
<td>II</td>
<td>40%</td>
<td>10%</td>
<td>50%</td>
</tr>
<tr>
<td>Extroverts</td>
<td>n = 7</td>
<td>n = 3</td>
<td>n = 10</td>
</tr>
<tr>
<td>[E]</td>
<td>35%</td>
<td>15%</td>
<td>50%</td>
</tr>
<tr>
<td>Total</td>
<td>n = 15</td>
<td>n = 5</td>
<td>n = 20</td>
</tr>
<tr>
<td></td>
<td>75%</td>
<td>25%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Story (1972) observes that although school teachers in general tend to be Sensing types, the mathematics teacher population is comprised mainly of Sensing–Judging types. Sensing types were majority in the Geometry Software Workshop too. Indeed, 75 percent of the participating preservice teachers were Sensing types (see Table 13).

Proportion of Introvert and Extrovert Types in the Geometry Software Workshop

Crooks, and Stein (1991) point out that Jung's identification of the two attitudes—introvert and extrovert—was an important contribution that "has endured and been incorporated into mainstream psychology as well as popular language" (p. 530). They say that according to Jung's theory, "a healthy person can strike a balance between these polar opposite traits by maintaining an
interest in things and people in the surrounding environment while not losing touch with his or her own unique individuality" (p. 530).

Research results report that 75 percent of the U.S.A. population is also comprised of Extroverts (Keirsey, and Bates, 1978; McCaulley, Macadaid, and Kainz, 1985; Myers, and McCaulley, 1985) and that Extrovert types are also the majority in regular classrooms, about 75 percent (Keirsey, and Bates, 1978). Social structures may favor an Extrovert attitude and the development of the Sensing function. The most common type in the population would be the Extrovert–Sensing type. Therefore, it is particularly important to find out the computer environment characteristics that may help Extrovert–Sensing types feel comfortable when they work or learn with computers.

Because research studies report that the use of computers in education may appeal more to Introvert students than to Extrovert students—Hoffman, Waters, and Nerry, 1981; Smith, 1971; White, and Smith, 1974—fewer Extroverts than Introverts were expected in the workshop. However, the same number of extroverts and introverts participated in the study, that is, ten Introverts and ten Extroverts attended the geometry software demonstration (see Table 13).

There were two sections for the three session of software demonstration, one on Monday and one on Wednesday both from
7:00 to 8:00 p.m. After participants self-selected one of the two sections, the Monday section was comprised by 76 percent of Extroverts and the group attending on Wednesday was formed totally by Introvert students (see Table 14).

**Table 14. Distribution of Personalities by Section of Software Demonstration**

<table>
<thead>
<tr>
<th>MONDAY</th>
<th>WEDNESDAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFP</td>
<td>INFP</td>
</tr>
<tr>
<td>ENFP</td>
<td>ISTJ</td>
</tr>
<tr>
<td>ENFJ</td>
<td>ESTJ</td>
</tr>
<tr>
<td>ESTJ</td>
<td>ISTJ</td>
</tr>
<tr>
<td>ESTJ</td>
<td>ISTJ</td>
</tr>
<tr>
<td>ESFJ</td>
<td>ISTJ</td>
</tr>
</tbody>
</table>

It was observed that students in the first group interacted a lot and were playful and joyful, whereas students in the second group were quiet, and there was almost no interaction among them.

**Identifying the Four MBTI Teachers**

Table 15 shows the frequency of the nine MBTI types that the Geometry Software Workshop attracted.
Table 15. Frequency of MBTI Types Participating in the Geometry Software Workshop

<table>
<thead>
<tr>
<th>Functions Used in Myers, and McCaulley's (1985) and Silver, and Hanson's (1985) Teachers' Characterizations</th>
<th>$f$</th>
<th>MBTI Types</th>
<th>$f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>NF</td>
<td>4</td>
<td>ENFP</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ENFJ</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INFP</td>
<td>1</td>
</tr>
<tr>
<td>NT</td>
<td>1</td>
<td>INTP</td>
<td>1</td>
</tr>
<tr>
<td>ST</td>
<td>9</td>
<td>ESTJ</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ISTJ</td>
<td>5</td>
</tr>
<tr>
<td>SF</td>
<td>6</td>
<td>ESFJ</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ISFJ</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ISFP</td>
<td>1</td>
</tr>
</tbody>
</table>

The results of the theoretical sampling (this process is explained in Chapter 3) suggests that the analysis should be focused on the following pairs of functions: NF, NT, ST, SF. The four cases that will be reported here, ENFP, INTP, ISTJ, and ISFP, have some preferences for these pairs of functions respectively. Table 16 contains the description of these personalities as given by Myers, and McCaulley (1985).
Table 16. Description of the Four Selected Teachers

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENFP</strong></td>
<td>Warmly enthusiastic, high-spirited, ingenious, imaginative. Able to do almost anything that interests them. Quick with a solution for any difficulty and ready to help anyone with a problem. Often rely on their ability to improvise instead of preparing in advance. Can usually find compelling reasons for whatever they want.</td>
</tr>
<tr>
<td><strong>INTP</strong></td>
<td>Quiet and reserved. Especially enjoy theoretical or scientific pursuits. Like solving problems with logic and analysis. Usually interested mainly in ideas, with little liking for parties or small talk. Tend to have sharply defined interests. Need careers where some strong interest can be used and useful.</td>
</tr>
<tr>
<td><strong>ISTJ</strong></td>
<td>Serious, quiet, earn success by concentration and thoroughness. Practical, orderly, matter-of-fact, logical, realistic, and dependable. See to it that everything is well organized. Take responsibility. Make up their own minds as to what should be accomplished and work toward it steadily, regardless of protests or distractions.</td>
</tr>
<tr>
<td><strong>ISFP</strong></td>
<td>Quiet, friendly, responsible, and conscientious. Work devotedly to meet their obligations. Lend stability to any project or group. Thorough, painstaking, accurate. Their interests are usually not technical. Can be patient with necessary details. Loyal, considerate, perceptive, concerned with how other people feel.</td>
</tr>
</tbody>
</table>

The analysis of the data related to Research Questions 2 and 3 will be focused on these four teachers.
Research Question 2

Is there a difference between observed patterns of teaching strategies and evaluation methods in regular classrooms, with no use of computers, and the preferred teaching strategies and evaluation methods of participating preservice secondary mathematics teachers when they plan to use computers and the software Geometric Supposer and Geometer's Sketchpad in their high school geometry classes?

This section describes, first, the type of triangulation used to validate the results of the data analysis carried out to answer Research Question 2. Second, the 19 computer environments will be described in general terms. Third, the preferred teaching strategies, teaching styles, and evaluation methods of the four selected preservice teachers. Finally, the results of the triangulation are reported.

**Triangulation**

The verification and validation of the data analysis carried out in the present study was based on two types of triangulation: (1) reconciling qualitative and quantitative data, and (2) multiple perspectives from multiple observers (Patton, 1980).

**Triangulation of methods.** The characterization given by this investigator of the four cases reported in this chapter is compared with the characterization given by Silver, and Hanson (1985), which is based on MBTI studies carried out in the quantitative tradition.
**Triangulation of analysts.** A researcher was involved who independently analyzed the same qualitative data set taken from the interviews, and her categorization was compared with both this investigator's, and Silver, and Hanson's.

**The Computer Environments**

Figure 12 includes the categories (teachers were encouraged to add more categories if they considered it necessary) that were given to preservice teachers to select from for designing a computer environment. Note that because of multiple selection some categories do not add up to 19, that is, to the number of participating teachers.

![Table of Technology and Topics](image)

**Figure 12. Frequency of Selected Categories**
Appendix H includes a copy of the handout that was given to participants. This handout includes the guidelines for writing the geometry activity. The geometry activity included three parts: (a) the design of a computer environment, (b) an activity to be carried out with the geometry software of their selection—the Geometric Supposer or the Geometer's Sketchpad—and (c) an evaluation form. Figure 12 reports the frequency of the selected categories for designing computer environments as well as the categories (in brackets) that some participants added to the handout.

Although 20 students attended the demonstration of the Geometric Supposer and the Geometer's Sketchpad, just 19 completed the geometry activities and the interviews. The data gathered from the activities suggest that the use of software like the Geometer's Sketchpad may encourage preservice teachers to teach high school geometry based on the analysis of geometrical relationships. Nine preservice teachers planned to emphasize analysis and just two cases out of 19 selected the drill-and-practice category.

The results show that 18 preservice teachers preferred the Geometer's Sketchpad and just one selected the Geometric Supposer. Eleven preservice teachers selected triangles, three quadrilaterals, three circles, and two teachers created categories of their own: polygons, and angles. Some students followed the structure of the Geometry Software Workshop booklets that
included activities at the first three van Hiele levels (level 0, level 1, and level 2), that is why these categories add up to more than 19. All of them preferred to teach in a computer laboratory. Twelve preservice teachers favored individual work, four, the work in groups, and three, cooperative learning.

It should be noted that the information gathered through the geometry activity and the computer environment could be misleading. Apparently, the majority of preservice teachers would use computers to explore geometrical relationships, However, the interviews revealed profound differences in the way that participating preservice teachers planned to use computers and geometry software in their high school geometry classes; although they may have selected the same elements for designing their computer environments. These differences will be discussed latter in this and the following section.

Table 17 shows the preferences of each of the 19 preservice teachers who completed the study. The first row of this table reports data under the following seven categories: (a) preferred MBTI type, (b) preferred software, (c) preferred topic, (d) content, (e) van Hiele level, (f) preferred setting, and (g) type of student's work, that is, the first column of this table contains the preferred Jungian functions of participating teachers, the second column shows the Software that each type selected and it may be observed that it was a Sensing–Thinking teacher who selected the Geometric
Supposer. The third column lists the *Topic* that each type of teacher selected. The fourth column contains the *Content* that participating teachers wanted their students to learn with their geometry activity. A closer analysis will show some differences in the type of content that different teachers prefer to teach (definitions, basic skills like drawing and construction of geometrical figures and shapes, or geometrical relationships). The fifth column indicates the *van Hiele level* in which the activity was set. This column shows that some students plan to use the Geometer's Sketchpad in different ways: (1) to introduce a concept (level 0); (2) to introduce a concept and explore geometrical relationships (level 0, 1, and 2); or (3) to develop conjectures and verify their geometry proofs (level 2 and 3). When participating students were asked how they would use the Geometer's Sketchpad to teach geometry proofs, they answered, for instance, that:
### Table 17. Computer Environments

<table>
<thead>
<tr>
<th>SOFTWARE</th>
<th>TOPIC</th>
<th>CONCEPT</th>
<th>Van Hiele Level</th>
<th>SETTING</th>
<th>CLASS INTERACTION</th>
<th>EMPHASIS ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISFJ</td>
<td>Sketchpad</td>
<td>Circles</td>
<td>Chords in a circle</td>
<td>2</td>
<td>Lab</td>
<td>Individual</td>
</tr>
<tr>
<td>ISFJ</td>
<td>Sketchpad</td>
<td>Triangles</td>
<td>Perimeter &amp; area</td>
<td>3</td>
<td>Lab</td>
<td>Groups</td>
</tr>
<tr>
<td>ISFJ</td>
<td>Sketchpad</td>
<td>Triangles</td>
<td>Congruency</td>
<td>2</td>
<td>Lab</td>
<td>Individual</td>
</tr>
<tr>
<td>ISTJ</td>
<td>Sketchpad</td>
<td>Triangles</td>
<td>Medians are congruent</td>
<td>3</td>
<td>Lab</td>
<td>Groups</td>
</tr>
<tr>
<td>ESFJ</td>
<td>Sketchpad</td>
<td>Triangles</td>
<td>Measure of Angles</td>
<td>0, 1</td>
<td>Lab</td>
<td>Groups</td>
</tr>
<tr>
<td>ENFP</td>
<td>Sketchpad</td>
<td>Triangles</td>
<td>$\sum &lt;= 180^0$</td>
<td>0</td>
<td>Lab</td>
<td>Individual</td>
</tr>
<tr>
<td>INTP</td>
<td>Sketchpad</td>
<td>Quad.</td>
<td>Area of a parallelogram and a trapezoid</td>
<td>2</td>
<td>Lab</td>
<td>Individual</td>
</tr>
<tr>
<td>ISTJ</td>
<td>Sketchpad</td>
<td>Triangles</td>
<td>Pythagorean Theo.</td>
<td>0</td>
<td>Lab</td>
<td>Individual</td>
</tr>
<tr>
<td>ESFJ</td>
<td>Sketchpad</td>
<td>Parallel lines</td>
<td>Angles formed by parallel lines cut by a transversal</td>
<td>2</td>
<td>Lab</td>
<td>Individual</td>
</tr>
<tr>
<td>ESTJ</td>
<td>Sketchpad</td>
<td>Polygons</td>
<td>Platonic solids</td>
<td>1</td>
<td>Lab</td>
<td>Individual</td>
</tr>
<tr>
<td>ESFJ</td>
<td>Sketchpad</td>
<td>Quad.</td>
<td>Properties of quadrilaterals</td>
<td>0</td>
<td>Lab</td>
<td>Cooperatively</td>
</tr>
<tr>
<td>ISTJ</td>
<td>Sketchpad</td>
<td>Triangles</td>
<td>Intersecting chords</td>
<td>2, 3</td>
<td>Lab</td>
<td>Individual</td>
</tr>
<tr>
<td>ENFP</td>
<td>Sketchpad</td>
<td>Circles</td>
<td>Segment bisector construction</td>
<td>1, 2</td>
<td>Lab</td>
<td>Cooperatively</td>
</tr>
<tr>
<td>ENFJ</td>
<td>Sketchpad</td>
<td>Triangles</td>
<td>Lines in a triangle</td>
<td>1</td>
<td>Lab</td>
<td>Individual</td>
</tr>
<tr>
<td>ISTJ</td>
<td>Sketchpad</td>
<td>Triangles</td>
<td>$\sum &lt;= 180^0$</td>
<td>1</td>
<td>Lab</td>
<td>Individual</td>
</tr>
<tr>
<td>ESTJ</td>
<td>Supposer</td>
<td>Quad.</td>
<td>Area of parallelograms</td>
<td>2</td>
<td>Lab</td>
<td>Cooperatively</td>
</tr>
<tr>
<td>ISFJ</td>
<td>Sketchpad</td>
<td>Triangles</td>
<td>Angle bisector &amp; congruency</td>
<td>1, 2</td>
<td>Lab</td>
<td>Individual</td>
</tr>
<tr>
<td>ESTJ</td>
<td>Sketchpad</td>
<td>Circles</td>
<td>Drawing lines of a circle</td>
<td>1</td>
<td>Lab</td>
<td>Groups</td>
</tr>
<tr>
<td>ENFP</td>
<td>Sketchpad</td>
<td>Triangles</td>
<td>Definition of triangles</td>
<td>0</td>
<td>Lab</td>
<td>Individual</td>
</tr>
</tbody>
</table>

**Note:** Categories with an * were not included in the options that were originally given to participating preservice teachers. Preservice teachers were encouraged to add more categories as they needed them to describe their computer environments.
INTP: It seems you can use it to verify for . . . It seems to me you can see it more to develop conjectures that you can then prove on the side using logical tools. Now that you have a conjecture you can show that it works with many different triangles that you draw on the Sketchpad. But I guess, I usually I'd try to teach students that is not a proof that just showing that it works in those several instances. Maybe it helps to feel more confident that's true, but a proof is actually a logical reasoning kind of thing.

The Setting column shows that all participating teachers wanted to teach in a computer laboratory rather than having a computer for the whole class. Although several teachers plan their students to work individually, the interviews showed that there were different reasons for selecting this category. The last column indicates the Type of Student's Work the preservice teachers plan to encourage when they teach geometry with their preferred geometry software. Two teachers selected the drill-and-practice category these were Sensing–Feeling teachers.

Preferred Teaching Strategies, Teaching Styles, and Evaluation Methods of Four Selected Teachers

This section reports, first, the preferred teaching strategies, teaching styles, and evaluation methods of the four selected
teachers. Second, the results of the triangulation, that is, the results of comparing the patterns observed in this study with patterns observed by other researchers.

**Teaching Strategies**

This section reports the preferred teaching strategies of four teachers. The teachers' responses that illustrate what they would do to facilitate learning were considered teaching strategies. The teaching strategies that the four selected teachers would apply when teaching geometry with the Geometers' Sketchpad are different and listed in what follows: (a) the ENFP teacher explains that she would "get the basics down and then after they [her students] got the basics down then I would explain," (b) the INTP teacher would "tell the students what we want them to work on using what we already knew," (c) the ISTJ teacher said that he would "have this [the activity that he wrote for the workshop] as a little project and maybe given the step-by-step instructions and then ask them certain questions," (d) the ISFP would set the task in front of the classroom and ask her students to help her to find out the solution. She said "have the class help me like where the congruency would be, present the two separately and then have them be able to go ahead and put them together into one triangle themselves." These different types of teaching strategies were categorized using the Silver, and Hanson's (1985) descriptors (see appendix D). The characterization of the preferred teaching
strategies of the four selected preservice teachers was based on
their responses to item 8 of the interview that asks: "How are you
going to present this activity?" (see Table 18) and the geometry
activity (see Table 19) that they either designed or selected from the
geometry scenarios of the Geometry Project (Appendix G).

<table>
<thead>
<tr>
<th>Table 18. Preferred Teaching Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Item 8. How are you going to present this activity?</strong></td>
</tr>
<tr>
<td><strong>ENFP</strong></td>
</tr>
<tr>
<td><strong>INTP</strong></td>
</tr>
<tr>
<td><strong>ISTJ</strong></td>
</tr>
<tr>
<td><strong>ISFP</strong></td>
</tr>
<tr>
<td>NF Teacher</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td><strong>The Activity</strong>&lt;br&gt;This lesson is for beginning geometry students. With this lesson I plan on showing students that the angles of a triangle add up to 180 degrees. I also want to show students that angles on a straight line also add up to 180 degrees. I will have the students construct a triangle. I will have the students construct a triangle at the same time as I am constructing one on Geometer’s Sketchpad. They will measure each angle and note which ones add up to 180 degrees. They will also learn that two angles on a straight line will also add up to 180 degrees. When the students are doing the evaluation, they are to use Geometer’s Sketchpad to figure out the problems. They must turn in a printout of their work along with their written work.</td>
</tr>
<tr>
<td><strong>SF Teacher</strong>&lt;br&gt;The objective of my activity is for students to discover the relationship between angle and congruent triangles. The process I would like them to go through depends on their knowledge of angles and triangles. The students’ prior knowledge must include the definition of angle bisectors and what makes a triangle congruent. The students will first construct a triangle on the computer. The angles and sides must be measured. The students should do this several times and compare the results of the measurements. I would like the students to use the results to analyze relationships between congruence and angle bisectors—if there any.</td>
</tr>
</tbody>
</table>
The NF (Intuitive-Feeling) Teacher. The NF preservice teacher wants her students to "figure out" what the sum of the internal angles of a triangle adds up to from her explanation and the examples she provides to the class (see Table 19). She does not want to give them the answer; rather, she plans to use the software to encourage her students to find out the result, "so they can explore . . . stuff on their own," as she explains during the interview. The preferred teaching strategy of this teacher might be referred to as both non-directive teaching and creative problem solving.

The NT (Intuitive-Thinking) Teacher. The NT preservice teacher wants to use the concepts of decomposition and recomposition to motivate his students to discover the formulae for calculating the area of a parallelogram and a trapezoid. The activity and the interview suggest that the NT teacher would use inquiry to facilitate concept formation: "using what we already knew about these figures to try to find out a method for calculating the area of the trapezoid and the parallelogram . . . see if that would help them to find formulas for the area."

The ST (Sensing-Thinking) Teacher. The ST preservice teacher, reported in these notes, wants to use this activity to help his students to become familiar with the Geometer's Sketchpad and to "learn" the Pythagorean Theorem. It is not clear what he plans, whether use the software to verify the theorem through the
presentation of several particular cases, or use the theorem for the
demonstration of the software. In any case, what it is clear is that
he does not plan his students to discover the geometrical
relationship involved in the Pythagoras' theorem. He may use the
software as mnemonic tool to help their students to remember the
formula. His activity and his response to item 8 of the interview
suggest that he would promote procedural learning emphasizing
the learning of facts: "have this as a little project and maybe given
the step-by-step instructions and then ask them certain questions
that I had, you know, "from your calculations, what do you see as
the relationship?"

The SF (Sensing-Feeling) Teacher. The SF preservice teacher
wants her students to discover "the relationship between angle
bisectors and congruent triangles." Her activity and her response
to this part of the interview suggest she may use group discussion
to encourage her students discover, for instance, that the angle
bisector of an equilateral triangle forms two congruent triangles in
the interior of the given triangle but that may not be true for all
triangles.

Based on the previous analysis of the geometry activities of the
four selected teachers (see Table 19) and the segments of the
interview included in Table 18 the preferred teaching strategies of
these teachers were categorized as follows:
• The NF teacher may favor creative problem solving.
• The NT teacher may encourage students to develop concept formation through an inquiry process.
• The ST teachers wants to use step-by-step instruction.
• Finally, the SF teacher plans to encourage group discussion to encourage her students to discover geometry relationships.

The categorization of the preferred teaching strategies of the NF, NT, and SF teachers suggests that these teachers will encourage exploration and discovery of geometrical relationships when they plan to use the Geometer’s Sketchpad in their high school geometry classes. Therefore the Geometer’s Sketchpad seems to enhance the teaching strategies of the NF, NT, and SF teachers. However, the preferred teaching strategy of the ST teacher reported here may not match a computer environment that encourages exploration, discovery, and demonstration of geometrical relationships. Because of his inclination to use programmed instruction like the following segment of the interview may suggest, "maybe give them the step-by-step instructions and then ask them certain questions that I had."

**Preferred Teaching Styles**

The segments of the interview included in Table 20 illustrate the preferred teaching styles of the four selected teachers when they plan to teach geometry with the Geometer’s Sketchpad.
<table>
<thead>
<tr>
<th>Item 12a. What is going to be the role of the teacher?</th>
<th>Silver, and Hanson’s Teaching Styles Observed in this Study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENFP</strong> To present the information and I think that the teacher shouldn’t just stand and lecture the whole time. Students need to explore it on their own and the teacher can kind of be a guide.</td>
<td>• Facilitator</td>
</tr>
<tr>
<td><strong>INTP</strong> I would say more facilitating and advising so, maybe a little bit of lecture just at the beginning to get things started but then just mostly students working on their own and... If some students are having trouble then the teacher might stop and ask them some questions about what they are doing and try to guide them in the right direction.</td>
<td>• Facilitator</td>
</tr>
<tr>
<td><strong>ISTJ</strong> See how they are doing, make sure that they are on task and not, you know, in some other program. I think just as a monitor and mainly to answer questions because there are going to be those who do ask questions.</td>
<td>• Instructional Manager</td>
</tr>
<tr>
<td><strong>ISFP</strong> To tell the students kind of what they should be looking for and let the students go individually on their own.</td>
<td>• Facilitator</td>
</tr>
</tbody>
</table>

The exploration of preferred teaching styles was based mainly on the interview data. The answers to item 12a asking: "What is going to be the role of the teacher?" reflect their preferred teaching styles and their are described in what follows.

**The NF (Intuitive–Feeling) Teacher.** The NF preservice teacher says that "students need to explore it on their own and the teacher can kind of be a guide." This teacher plans to facilitate learning encouraging her students to explore geometry relationships own their own.
The NT (Intuitive-Thinking) Teacher. The NT preservice teacher says that the teacher should be "facilitating and advising . . . maybe a little bit of lecture just at the beginning to get things started but then just mostly students working on their own." This teacher plans to play the role of facilitator when teaching geometry with the Geometer's Sketchpad. He does not want to lecture.

The ST (Sensing-Thinking) Teacher. The ST preservice teacher thinks that: "just as a monitor and mainly to answer questions. His answer suggests that he may play the role of "the authority in the classroom."

The SF (Sensing-Feeling) Teacher. The answer of the ENFP teacher suggests this teacher may want help students to build their own knowledge: "To tell the students kind of what they should be looking for and let the students go individually on their own." The SF teacher may also play the role of facilitator when planning to teach geometry with the aid if the Geometer's Sketchpad.

Evaluation Methods

Table 21 includes the interview segments that were used to categorize the preferred evaluation methods of the four selected teachers when they were asked: "How are you going to evaluate understanding?"
<table>
<thead>
<tr>
<th>Item 9. How are you going to evaluate understanding?</th>
<th>Silver, and Hanson’s Evaluation Methods Observed in this Study</th>
</tr>
</thead>
</table>
| **ENFP** Watch what they are doing to see if they really understand what’s going on and ask them questions and talk to them. I think it’s hard to come up with a written evaluation, you know? . . . I think as a teacher for me to really know that they understood what’s going on I would need to talk to them interact with my class. **Have them explain.** | • Observations  
• Flexibility of Response |
| **INTP** I would try to evaluate it on the basis of whether they recognize . . . the fact that with this information that you already know that you can find the information that you are looking for. I would try to evaluate it in some way to give them feedback . . .this is what I was looking for you to know and these are the problems you have. | • Demonstration of Abilities to Apply, Interpret, Analyze |
| **ISTJ** Ask them the relationship and they are going to have to write it out . . . I would see it in their homework . . . I would ask questions about we just did . . . and I would ask that group why individually so. | • Close ended questions |
| **ISFP** I think what I would do for an evaluation, instead of just having them write down figures, I would have them write down relationships, maybe a couple of sentences like short answer instead of just directly copying off . . .like ask what did you find from this instead of just saying what were the measurements. **Instead of asking like close ended questions. More essay questions.** | • Self Reporting  
• Collection of Unobtrusive Data |
The NF (Intuitive-Feeling) Teacher. NF teacher prefers to observe her students while they are working: "Watch what they are doing to see if they really understand what's going on and ask them questions and talk to them." This teacher prefers to observe her students while working on the computer rather than giving them a questionnaire at the end of the lesson.

The NT (Intuitive-Thinking) Teacher. The NT teacher would base his evaluation on the students' capability to interpret and analyze. For instance he says, that he wants his students to recognize that "with this information that you already know that you can find the information that you are looking for." Again, like the NT teachers that Silver, and Hanson observed, the evaluation procedure of this NT teacher requires that students demonstrate the ability to analyze, interpret, and apply.

The ST (Sensing-Thinking) Teacher. The ST teacher that is reported here was selected to represent the typical characterization of this type of teacher. The ST teacher reported here plans to use close-ended questions as the following segment of the interview illustrates: "Ask them the relationship and they are going to have to write it out," which characterizes his preference for facts and impersonal analysis.

The SF (Sensing-Feeling) Teacher. Finally, the SF teacher wants her students to describe the geometrical relationships that students observed on the screen while working with the
Geometer's, and she wants them to write a "couple of sentences" rather than "asking like close-ended questions." She says that she would ask "more essay questions." The evaluation procedures that this SF teacher would use fall into the Silver, and Hanson categorization too.

**Triangulation of the Preferred Teaching Strategies, Teaching Styles, and Evaluation Procedures of the Four Selected Cases**

Two types of triangulation were used to verify the previous characterization of the preferred teaching strategies, teaching styles, and evaluation methods of the four selected teachers, namely, triangulation of methods and triangulation of analysts. Three categorizations of teaching strategies, teaching styles, and evaluation methods were compared. Agreement was concluded when there was intersection among or between categories. In those cases where there was not intersection this investigator used her categorization as recommended by Glaser, and Strauss:

> If there is only one sociologist involved, he himself knows what he knows about what he has studied and lived through. They are his perceptions, his personal experience, and his own hard-won analysis. . . . What he has confidence in is not a scattered series of analysis, but a systematic ordering of them into an integrated theory. (p. 225)
Triangulation of Methods

The Silver, and Hanson's (1985) categorization of teaching strategies, teaching styles, and evaluation methods was used in the triangulation of methods.

Triangulation of Analysts

The triangulation of analysts implies that "two or more persons independently analyze the same qualitative data set and compare their findings" (Patton, 1980, p. 331).

Table 22 contains the descriptors used by Silver, and Hanson (1985) to categorized the preferred teaching strategies, teaching styles, and evaluation methods of the four MBTI types of teachers. Table 23 summarizes the external researcher's categorization of the teaching strategies, teaching styles, and evaluation methods of the four selected teachers.
### Table 22. Silver, and Hanson's Categorization of Strategies, Teaching Styles, and Evaluation Methods

<table>
<thead>
<tr>
<th>Teaching Strategies</th>
<th>Teaching Styles</th>
<th>Evaluation Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NF</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-directive teaching</td>
<td>Facilitators</td>
<td>Fluency of expression</td>
</tr>
<tr>
<td>Synectics</td>
<td>Stimulators</td>
<td>Flexibility of response</td>
</tr>
<tr>
<td>Boundary-breaking</td>
<td>Creators</td>
<td>Originality of response</td>
</tr>
<tr>
<td>Analyzing and working with moral dilemmas</td>
<td></td>
<td>Elaboration of detail</td>
</tr>
<tr>
<td>Creative problem solving</td>
<td></td>
<td>Development of aesthetic criteria</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Producing creative products</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Observations of value systems in action</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unobtrusive data collection</td>
</tr>
<tr>
<td><strong>NT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inquiry training</td>
<td>Intellectual challengers</td>
<td>Open ended questions</td>
</tr>
<tr>
<td>Concept formation</td>
<td>Inquirers</td>
<td>Essays</td>
</tr>
<tr>
<td>Use of Socratic methods of questioning</td>
<td>Theoreticians</td>
<td>Demonstration of abilities to apply, synthesize, interpret, integrate, analyze, evaluate.</td>
</tr>
<tr>
<td>Problem-solving</td>
<td></td>
<td>Think divergently</td>
</tr>
<tr>
<td>Comprehensive planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ST</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programmed instruction</td>
<td>Trainers</td>
<td>Objective tests</td>
</tr>
<tr>
<td>Command style teaching</td>
<td>Information givers</td>
<td>Checklists</td>
</tr>
<tr>
<td>Mastery learning</td>
<td>Instructional manager</td>
<td>Behavioral objectives</td>
</tr>
<tr>
<td>Drill and repetition</td>
<td></td>
<td>Use of mechanical devices</td>
</tr>
<tr>
<td>Memorization</td>
<td></td>
<td>Demonstration of specific skills</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Criterion referenced tests</td>
</tr>
<tr>
<td><strong>SF</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group investigations</td>
<td>Nurturers</td>
<td>Personal journals</td>
</tr>
<tr>
<td>Classroom meetings</td>
<td>Supporters</td>
<td>Sociograms</td>
</tr>
<tr>
<td>Peer tutoring</td>
<td>Empathizers</td>
<td>Oral reports</td>
</tr>
<tr>
<td>Lab training</td>
<td></td>
<td>Ranking procedures</td>
</tr>
<tr>
<td>Team, games, and tournaments</td>
<td></td>
<td>Trained observations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collection of unobtrusive data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Self reporting</td>
</tr>
</tbody>
</table>
Table 23. External Researcher’s Characterization of Teaching Strategies, Evaluation Methods, and Classroom Interactions

<table>
<thead>
<tr>
<th></th>
<th>Teaching Strategies</th>
<th>Evaluation Methods</th>
<th>Teaching Styles</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFP</td>
<td>Command Style Teaching</td>
<td>Unobtrusive data</td>
<td>Facilitator</td>
</tr>
<tr>
<td></td>
<td>Concept Formation</td>
<td>Observations</td>
<td>Information giver</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Demonstration of specific skills</td>
<td>Instructional manager</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Supporter</td>
</tr>
<tr>
<td>INTP</td>
<td>Facilitator</td>
<td>Demonstration of abilities to apply, interpret,</td>
<td>Facilitator</td>
</tr>
<tr>
<td></td>
<td>Instructional Manager</td>
<td>analyze</td>
<td>Instructional manager</td>
</tr>
<tr>
<td>ISTJ</td>
<td>Command Style Teaching</td>
<td>Demonstration of specific skills</td>
<td>Facilitator</td>
</tr>
<tr>
<td></td>
<td>Concept Formation</td>
<td>Close-ended questions</td>
<td>Information giver</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nurturer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Instructional manager</td>
</tr>
<tr>
<td>ISFP</td>
<td>Information giver</td>
<td>Essay</td>
<td>Information giver</td>
</tr>
<tr>
<td></td>
<td>Instructional manager</td>
<td>Open-ended Questions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Self reporting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ITEM 8</td>
<td>ITEM 9</td>
<td>ITEM 12a</td>
</tr>
</tbody>
</table>

Table 24 includes the three categorizations of the teaching strategies of four types of teachers. Table 25 facilitates the comparison of the three categorizations of teaching styles. Table 26 summarizes the results of the categorization of evaluation methods. These tables illustrate how the categorization given by this investigator was verified.
Table 24. Summary of Triangulation of Methods and Triangulation of Analysts for Item 8

How are you going to present this activity?

<table>
<thead>
<tr>
<th></th>
<th>External Researcher</th>
<th>Silver, and Hanson</th>
<th>This Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFP</td>
<td>Command style teaching • Concept formation</td>
<td>Non-directive teaching • Synectics • Breaking mind sets • Analyzing and working with moral dilemmas • Creative problem solving</td>
<td>Creative Problem solving</td>
</tr>
<tr>
<td>INTP</td>
<td>Facilitator • Instructional manager</td>
<td>Inquiry training • Concept formation • Use of Socratic methods of questioning • Problem-solving • Comprehensive planning</td>
<td>Inquiry • Concept Formation</td>
</tr>
<tr>
<td>ISTJ</td>
<td>Command style teaching • Concept formation</td>
<td>Programmed instruction • Command style teaching • Mastery learning • Drill and repetition • Memorization</td>
<td>Programmed Instruction</td>
</tr>
<tr>
<td>ISFP</td>
<td>Information givers • Instructional managers</td>
<td>Group investigations • Classroom meetings • Peer tutoring • Lab training • Team games and tournaments</td>
<td>Group Investigations</td>
</tr>
<tr>
<td>Type</td>
<td>External Researcher</td>
<td>Silver, and Hanson</td>
<td>This Investigator</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
<td>--------------------</td>
<td>-----------------------------------</td>
</tr>
</tbody>
</table>
| ENFP  | •Collection of unobtrusive data  
•Demonstration of specific skill  
•Observations                   | •Fluency of expression  
•Flexibility of response  
•Originality of response  
•Elaboration of Detail  
•Producing creative products  
•Observations of value systems in action  
•Unobtrusive data collection | •Observations  
•Flexibility of Response |
| INTJ  | •Demonstration of abilities to apply, interpret, analyze | •Open ended questions  
•Essays  
•Demonstration of Abilities to apply, synthesize, interpret, integrate, analyze, and evaluate  
•Think divergently | •Demonstration of Abilities to Apply, Interpret, Analyze |
| ISTJ  | •Demonstration of specific skills  
•Close ended questions          | •Objective tests  
•Checklists  
•Behavioral objectives  
•Use of mechanical devices  
•Demonstrations of specific skills  
•Criterion referenced tests  | •Close ended questions |
| ISFP  | •Essay  
•Open ended questions  
•Self reporting               | •Personal journals  
•Oral reports  
•Ranking procedures  
•Trained observations  
•Collection of Unobtrusive data  
•Self reporting               | •Self Reporting  
•Collection of Unobtrusive Data |
<table>
<thead>
<tr>
<th></th>
<th>External Researcher</th>
<th>Silver, and Hanson</th>
<th>This Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENFP</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Facilitator</em></td>
<td></td>
<td><em>Facilitators</em></td>
<td><em>Facilitator</em></td>
</tr>
<tr>
<td><em>Information giver</em></td>
<td></td>
<td><em>Stimulators</em></td>
<td></td>
</tr>
<tr>
<td><em>Instructional manager</em></td>
<td></td>
<td><em>Creators</em></td>
<td></td>
</tr>
<tr>
<td><em>Supporter</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>INTP</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Facilitator</em></td>
<td></td>
<td><em>Intellectual challengers</em></td>
<td><em>Facilitator</em></td>
</tr>
<tr>
<td><em>Instructional manager</em></td>
<td></td>
<td><em>Inquirers</em></td>
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<td></td>
<td></td>
<td><em>Theoreticians</em></td>
<td></td>
</tr>
<tr>
<td><strong>ISTJ</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Facilitator</em></td>
<td></td>
<td><em>Trainers</em></td>
<td><em>Instructional Manager</em></td>
</tr>
<tr>
<td><em>Information giver</em></td>
<td></td>
<td><em>Information givers</em></td>
<td></td>
</tr>
<tr>
<td><em>Nurturer</em></td>
<td></td>
<td><em>Instructional managers</em></td>
<td></td>
</tr>
<tr>
<td><em>Instructional manager</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ISFP</strong></td>
<td>*Information givers</td>
<td><em>Nurturers</em></td>
<td><em>Facilitator</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Supporters</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Empathizers</em></td>
<td></td>
</tr>
</tbody>
</table>

**Preferred teaching strategies.** The categorization of the preferred teaching strategies of the four selected teachers given by this investigator agrees with that proposed by Silver, and Hanson.

**Preferred teaching styles.** The categorization under teaching styles given by this investigator differs from that reported by Silver, and Hanson (1985). Three of the four selected teachers plan to play the role of facilitators, namely, the ENFP, the INTP, and the ISFP teachers while Silver, and Hanson (1985) reports different roles for each of these types. However, the preferred teaching style...
of the ISTJ teacher coincides with that reported by Silver, and Hanson.

**Preferred evaluation methods.** The pattern of preferred evaluation methods of the four teachers reported here correspond to that given by Silver, and Hanson (1985). The evaluation methods used in regular classrooms with no use of technology may be also used by teachers when they plan to teach high school geometry with the Geometer's Sketchpad.

On the one hand, the triangulation of methods shows that the categorization of the preferred teaching strategies and evaluation methods of the four selected teachers given by this investigator coincides with that given by Silver, and Hanson (1985), although the categorization under teaching styles differs from this authors' categorization. On the other hand, the results of the triangulation of analysts show that the categorization of teaching styles and evaluation methods of the four selected teachers given by this investigator coincide with the categorization given by the external researcher (see Tables 24, 25, and 26).

The results of both types of triangulation—triangulation of methods and triangulation of analysts—verify in some extension the original categorization of the preferred teaching strategies, teaching styles, and evaluation methods of the four selected cases given by this investigator.
Research Question 3

Do Intuitive and Sensing Types Differ in Their Use of Computers and Geometry Software?

This question is related to the previous one, indeed, some differences between Intuitive [N] and Sensing [S] preservice teachers have already been mentioned in terms of teaching strategies, teaching styles, and evaluation methods. This section focuses on the different ways participants plan to use computers and geometry software to teach high school geometry. The categories reported in this section are: (a) setting, (b) how will students work?, (c) classroom interactions, and (d) computer uses. The original set of categories included in the handout for the geometry activity did not include the two following categories: classroom interactions, and computer uses (see Figure 12). However, these categories were considered at the time of the interview. Figure 13 shows the categories and the subcategories related to the design of computer environments and computer uses being reported here.
Setting:
One computer
Computer Laboratory.

How will students work?
Cooperatively
Groups
Individually
Teams
Whole class

Emphasis on discussion
Emphasis on dividing the task
Emphasis on analysis
Emphasis on drill and practice
Emphasis on competition
Emphasis on lecturing
[Emphasis on construction]
[Emphasis on discovery]
[Emphasis on experimentation]
[Emphasis on exploring]

Computer Uses:
Discovery
Exploration of concepts
Problem solving
Programming
Review of basic skills
Todo calculations
To teach the curriculum

Figure 13. Categories Related to Setting, Type of Student's Work, Classroom Interactions, and Computer Uses

Preferred Classroom Interactions, and Computer Uses of Four Selected Teachers

The results of the data analysis reported here may provide other type of triangulation—triangulation of data sources. The triangulation of data sources "means comparing and cross-checking consistency of information derived at different times and by different means within qualitative methods" (Patton, 1980, p. 331). The previous section reported the categorization of teaching strategies, teaching styles, and evaluation methods. This section reports the categorization of preferred setting, type of student's work, classroom interactions, and computer uses. Later in this
section will be illustrated how the preferred classroom interactions might be related to preferred teaching strategies and teaching styles supporting the categorization that was given in the previous section.

**Classroom Interactions**

Classroom interactions refer to: (a) interaction of the student with the computer, (b) interaction of the teacher with the student, and (c) interactions among students. This part of the study explores the type of classroom interactions that the four selected teachers may allow in their classes when they plan to teach geometry with the Geometer's Sketchpad. The design of the computer environment and the responses to items 6, 7, and 12c were used to categorize the preferred classroom interactions of the four selected teachers. The categories of the computer environment related to classroom interactions are *setting*, and *type of student's work*.

The selection of *setting* reflects the way teachers want their students work in the computer environment. The selection of the *type of student's work*—how will students work?—reflects the interactions among students, and the interaction between the student and the computer that teachers may encourage in their computer environments.

First, the preferred setting of four participants will be reported. Second, the type of student's work they want to encourage with the
geometry activity that they designed for the study. The results of the triangulation of the data related to classroom interactions will be reported at the end of this section together with the triangulation of the data related to computer uses.

Setting. All participants preferred the computer laboratory setting over the setting in which the teacher works on the computer and students watch what the teacher does. All participants preferred to work in a computer laboratory if they had to teach geometry with computers (see Table 17) and their responses to item 6 asking "Why do you prefer your students work in a computer laboratory?" were very similar, that is, because students may work by themselves on the activities and manipulate the figures on the screen. The interviews revealed that different types of teachers will use the computer laboratory in different manners encouraging different types of classroom interactions.

The responses to item 6 of the interview show that teachers prefer this setting because encourages individual learning. Although the geometry activities show that the 19 participants selected the computer laboratory setting to teach geometry with the Geometer's Sketchpad, the interviews show that teachers may encourage different classroom interactions, that is, the interaction of the student with the computer, the interaction of the student with the teacher, and the classroom interaction among students.
Table 27 illustrates the reasons behind the selection of setting of the four selected teachers.

<table>
<thead>
<tr>
<th>Item 6. Why do you prefer your students work in a computer laboratory?</th>
<th>Reasons behind the Selection of Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFP</td>
<td>!also think it's important for every student to have a computer because it like promotes more <strong>individual exploration</strong>.</td>
</tr>
<tr>
<td>INTP</td>
<td>I feel like <strong>when students are actually interacting and manipulating the figures on their own that they remember better and understand better</strong> and that it's easier in that setting.</td>
</tr>
<tr>
<td>ISTJ</td>
<td>If you had a laboratory method you could go around to everyone, everyone is working on the same thing they could ask a partner if they get stuck because they are going through the same thing.</td>
</tr>
<tr>
<td>ISFP</td>
<td>Well I just think that provides them with an easier access to the computers and **it would be easier for me to teach being in a lab setting because then I would be able to have a computer in front of me also in which I might be able to put examples up on the screen in front of them.</td>
</tr>
</tbody>
</table>

The **NF (Intuitive–Feeling) Teacher.** NF teacher prefers "individual exploration." She says that a computer environment with one computer for each student "promotes more individual exploration."
Her preferred teaching strategy encourages creative problem solving; she wants her students figure out how to solve the problem that she states (see Tables 18 and 19). Her teaching style may encourage students explore on their own. The computer laboratory setting may facilitate that she implements her preferred teaching strategy.

The NT (Intuitive-Thinking) Teacher. The NT teacher thinks that "when students are actually interacting and manipulating the figures on their own . . . they remember better and understand better." He says that this interaction and manipulation of figures is easier in a computer laboratory "that it’s easier in that setting."

The INTP teacher wants his students to manipulate figures to find out the formulae of the parallelogram and the trapezoid (see Table 18). The individual exploration that the computer laboratory allows may facilitate students’ exploration.

The ST (Sensing-Thinking) Teacher. The ST teacher considers that teaching geometry in a computer laboratory facilitates control of the class. He says: "if you had a laboratory method you could go around to everyone, everyone is working on the same thing they could ask a partner if they get stuck because they are going through the same thing."

The reasons behind the selection of setting support the categorization of the preferred teaching strategies—programmed instruction, command style, and memorization—and teaching
style— instructional manager— of the ISTJ teacher given in the previous section.

**The SF (Sensing–Feeling) Teacher.** The ISFP teacher would like to use a computer laboratory when using computers to teach geometry because "it would be easier for me to teach" she explains "because then I would be able to have a computer in front of me also in which I might be able to put examples up on the screen in front of them." Her reasons behind the selection of setting supports the categorization of her preferred teaching strategy—group investigations projecting her computer screen on the blackboard with examples to the whole group.

**Type of student's work?** Participating teachers had to specify how students were going to work in the computer environment (see Figure 9). The computer environments designed by the four selected teachers included the following categories describing the type of student's work:

- The ENFP teacher selected: Individual work with emphasis on analysis.
- The INTP teacher selected: Individual work with emphasis on analysis.
- The ISTJ teacher selected: Individual work with emphasis on analysis.
- The ISFP teacher selected: Individual work with emphasis on discovery.
Table 28 contains the interview segments that better illustrate the type of classroom interactions—interactions between the student and computer—that these teachers may encourage when planning to teach geometry with the Geometer's Sketchpad.

**Table 28. Type of Student's Work**

<table>
<thead>
<tr>
<th>ENFP</th>
<th>I think so they can explore it, stuff on their own basically.</th>
<th>• Exploration</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTJ</td>
<td>Well... again I guess it seems like in the lab setting if they each had a computer then that would allow them to sort of follow their own ideas and work with the concept at their own pace and each one would then have a chance to manipulate figures.</td>
<td>• Exploration</td>
</tr>
<tr>
<td>ISTJ</td>
<td>Because I think that when I do computer work group wise, I don't get as much out of it if I'm not the one pressing the buttons... if I'm not doing the constructions I might be looking out the window cause he's doing it all.¹</td>
<td>• Exploration</td>
</tr>
<tr>
<td>ISFP</td>
<td>Because of my activity I thought it was more of a discovery kind of activity and I wanted them to get their own relationships out of it. It really wasn't something that needed discussion. I think it was more just looking at the screen and playing around with the mouse that it would be more helpful to the individual group.</td>
<td>• Exploration</td>
</tr>
</tbody>
</table>

¹ Chapter 3 describes the selection procedure of the four teachers reported here. One criterion was that the participant explains his or her point of view as a teacher. This is the only situation in which this preservice teacher explained his point of view as a student rather than as a teacher.
The four teachers plan their students work individually. Three of them, the ENFP, the INTP, and the ISTJ, want to put emphasis on analysis; and the ISFP teacher added a new category, "discovery." Although the four teachers want their students to explore geometrical relationships on their own, they differ in the reasons to select this category. The Intuitive (NF and NT) types will allow students to explore the relationships that may be interesting for the students while Sensing (SF and ST) types want students to explore those relationships suggested by the teacher. As the segments of the interview with the NF and the ST teachers may illustrate:

**ENFP:** It's important for every student to have a computer because it like promotes more individual exploration or whatever because I know that when I was learning geometry I was sitting there with my computer and you would teach us how to do something and then I thought in my mind well I wonder what would happen if I did this and I tried it on my own and did different things that maybe the whole class wasn't doing but I was kind of exploring it on my own and I think that is important. That's a big thing in learning.
ISTJ: If we are in the laboratory setting . . . make sure that they are on task and not in some other program. *I think that if you had a laboratory method you could go around to everyone, everyone is working on the same thing*, they [his students] could ask a partner if they get stuck because everyone is working on the same thing.

The segments of the interview show that the Sensing–Thinking [ISTJ] teacher wants to avoid in his computer environment precisely what Intuitive–Feeling [ENFP] teacher considers as very important in the process of instruction to facilitate learning

**Cooperative learning.** The two previous sections report the preferred setting and type of student's work of the four selected teachers. The results of the data analysis show that the reasons behind these preferences are related to the type of classroom interactions that these four teachers think facilitate learning, that is, students working individually exploring geometrical relationships on their own. This section reports the responses of the four selected teachers when they were asked to answer the following question: "when cooperative learning could be useful?"

The Intuitive types (NF and NT) think that a good combination of individual and cooperative work would be more beneficial than students working in groups all the time. The Sensing–Feeling type would combine individual work with group discussion. Finally, the
Sensing–Thinking preservice teacher thinks that cooperative learning in a computer environment is not helpful:

I don't know. Computer cooperative learning, like I said earlier I don't think is that helpful . . . I'm not really for cooperative learning using the computers. I think it can be implemented but it's just not my style.

Again Intuitives (NF and NT) and the Sensing–Feeling teachers seemed to be more flexible and accepted that in certain activities cooperative learning would be more helpful for students to learn; however, the Sensing–Thinking teacher did not consider cooperative learning as useful as individual learning in a computer environment. Table 29 illustrates the categorization of the responses of the four selected teachers related to the relevance of cooperative learning in a computer environment.
### Table 29. Cooperative Learning in Computer Environments

<table>
<thead>
<tr>
<th>Item 12c. When could cooperative learning be useful?</th>
<th>Classroom Interactions</th>
</tr>
</thead>
</table>
| **ENFP** I plan on in my classroom as teacher having individual work and also I think cooperative learning is very beneficial. | • Individual Work  
• Cooperative Work |
| **INTP** I think that most kinds of exploration activities can be done cooperatively, I would limit it to maybe half the time of cooperatively and the rest of the time work individually. | • Individual Work  
• Cooperative Work |
| **ISTJ** I don't know. Computer cooperative learning, like I said earlier I don't think is that helpful. I'm just more into the individualized computer instead of have four people sitting at the computer. I think it can be implemented but it's just not my style. I guess. | • Individual Work |
| **ISFP** I don't know if I would try it on a computer because I think that a computer is more individual. I guess maybe a discussion at the end might be useful but not actually while they are working on a computer but maybe after the, to kind of get together and discuss what they found and compare what they did on the computer is when I'd use it. | • Individual Work  
• Group Discussion |

**Note:** The four cases had selected individual work when they designed their computer environments. However, when they were asked when cooperative learning could be useful in a computer environment their responses varied.

Table 30 summarizes the results presented in the three previous sections—setting, type of student's work, and cooperative learning. The three previous sections were related to classroom interactions.
Table 30. Classroom Interactions in Computer Environments

<table>
<thead>
<tr>
<th></th>
<th>Setting</th>
<th>Teachers will put emphasis on</th>
<th>Classroom Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENFP</strong></td>
<td>Laboratory/Individual work</td>
<td>• Exploration</td>
<td>• Individual Work</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Cooperative Work</td>
</tr>
<tr>
<td><strong>INTP</strong></td>
<td>Laboratory/Individual work</td>
<td>• Exploration</td>
<td>• Individual Work</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Cooperative Work</td>
</tr>
<tr>
<td><strong>ISTJ</strong></td>
<td>Laboratory/Individual work</td>
<td>• Exploration</td>
<td>• Individual Work</td>
</tr>
<tr>
<td><strong>ISFP</strong></td>
<td>Laboratory/Individual work</td>
<td>• Exploration</td>
<td>• Individual Work</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Group Discussion</td>
</tr>
</tbody>
</table>

The four selected teachers would prefer to teach geometry with the Geometer's Sketchpad in a computer laboratory because this setting facilitates individual work and exploration of geometrical figures and relationships. The results show that these teachers may tend to encourage individual learning rather than cooperative learning.

Computer Uses

The information gathered through the geometry activity and the design of the computer environment could be misleading. Apparently, the majority of preservice teachers would use
computers to explore geometrical relationships. However, at the
time of the interview teachers gave different responses. They were
asked both how frequently they would use the computers, and how
they would use the geometry software they had selected. It was
observed that the four selected teachers differ in both the amount
of time they plan to use computers in their teaching and in the
way they would use them. For instance, the following segments of
the interviews with the ENFP and the ISFP teachers illustrate how
they differ in terms of the time they allow students work with the
computers.

**ENFP:** I think the computer should be used quite a bit because
customers are out there and in order to discover and to
advance into our society you need to use all the technology you
can; so I think that students should be very comfortable and
use their computers a lot but then I also believe that students
need to be able to do some of these skills on their own . . . they
need to know how to do it on their own.

**ISFP:** The computer will probably be used once a unit maybe
. . . I don't see myself using them very often because I don't
think they can learn basic background concepts on the
Geometer's Sketchpad.
Chapter 1 describes the problems that teachers may find when they plan to use computer in their classes, for instance, no easy access to computers. However, the context in which the question about how much participating preservice teachers would use the computers (item 12b) was a hypothetical situation. They were asked to imagine that there were computers in their classrooms, one for each student. They would not have to worry about any type of limitation.

Table 31 contains the interview segments that better illustrate the way in which each of the four selected teachers plan to use the Geometer's Sketchpad in their high school geometry classes.
Table 31. Preferred Use of Computers

<table>
<thead>
<tr>
<th>ENFP</th>
<th>12b. What is going to be the role of computers?</th>
<th>Use of Computers</th>
</tr>
</thead>
</table>
|      | I also believe that students need to be able to do some of these skills on their own . . . they also need to know how to do it on their own by hand with a compass, you know . . . **have the computer do the trivial stuff** that they already learnt how to do and then move on from there. | • To do constructions  
• To do calculations |
| INTP | I think **for exploration**, as far as **trying to come up with conjectures** and so forth I would use the computer a lot for that . . . maybe spend half of the time using the computer in that way and then assuming that proof were a big part of the course as well then the other half of the course might have to do with proof which I would see as more pencil and paper kind of thing . | • To generate conjectures |
| ISTJ | Well I think that one of the biggest mistakes that people do when they want to incorporate computers into their curriculum, they model, they bring the curriculum around the computer but I think you should **bring the computer around the curriculum**. | • To teach the curriculum |
| ISFP | I would use it maybe right **before a test for like a review for concepts or something like that**. Not very often I don’t see myself using them right now very often because I don’t think they can learn basic background concepts on the. | • Review of basic skills |

**Note:** This question refers to the use of computers in the whole geometry course, not just for the geometry activity that was selected or designed for the study.

The computer environments reported in Table 17 suggest that the four selected teachers may use the Geometer's Sketchpad in similar ways. The interview was designed to explore the reasons behind the selections of the participants. In a first approach even
the answers to the interviews looked similar. It was a close analysis focused on the four selected teachers that patterns emerged. It was found that these teachers also differ in the way they plan to use the Geometer’s Sketchpad.

The data analysis suggest that the preferred way of the Geometer’s Sketchpad of the four selected teachers might be described as follows.

The NF (Intuitive-Feeling) Teacher. NF teacher considers important that students know how to do geometrical constructions: she wants her students to work on the software once they already learnt the concept in the regular class: "they also need to know how to do it on their own by hand with a compass . . . have the computer do the trivial stuff that they already know." She would like students use the computers as a tool to carry out "the trivial stuff." This teacher may use the Geometer’s Sketchpad like an electronic rule and compass, and/or a calculator.

The NT (Intuitive-Thinking) Teacher. The NT teacher would encourage his students to use the Geometer’s Sketchpad to generate conjectures. He says he would use the software "for exploration, as far as trying to come up with conjectures and so forth I would use the computer a lot for that."

The ST (Sensing-Thinking) Teacher. The ST teacher would use the computers to teach the curriculum. He observes that: "one of
the biggest mistakes that people do when they want to incorporate computers into their curriculum [is that] they bring the curriculum around the computer but I think you should bring the computer around the curriculum."

The SF (Sensing-Feeling) Teacher. The SF teacher would use the Geometer's Sketchpad to review concepts and definitions like the following segment of the interview may illustrate: "before a test for like a review for concepts or something like that." Using the Silver, and Hanson's (1985) descriptors we could say that she may use the software to review basic skills.

Triangulation of Classroom Interactions, and Computer Uses of Four Selected Teachers

The categories included in this section are not considered in previous MBTI studies; therefore triangulation of classroom interactions and computer uses will be based only on the triangulation of analysts. Table 32 lists the interview items related to these two categories. Table 33 summarizes the external researcher's categorization of the preferred classroom interactions and computer uses of the four selected teachers.
Table 32. Interview Items Related to Classroom Interactions and Computer Uses

<table>
<thead>
<tr>
<th>Classroom Interactions</th>
<th>Computer Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Item 6. Why do you prefer your students work in a computer laboratory?</td>
<td>• Item 12b. What is going to be the role of computers?</td>
</tr>
<tr>
<td>• Item 7. Why do you want your students to work individually?</td>
<td></td>
</tr>
<tr>
<td>• Item 12c. When cooperative learning would be useful?</td>
<td></td>
</tr>
</tbody>
</table>

Table 33. External Researcher's Characterization of Preferred Categorization of Preferred Classroom Interactions and Computer Uses

<table>
<thead>
<tr>
<th></th>
<th>Classroom Interactions</th>
<th>Use of Computers</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFP</td>
<td>• Individual work</td>
<td>• To do calculations</td>
</tr>
<tr>
<td></td>
<td>• Individual exploration</td>
<td></td>
</tr>
<tr>
<td>INTP</td>
<td>• Individual work</td>
<td>• Exploration of concepts</td>
</tr>
<tr>
<td></td>
<td>• Individual exploration</td>
<td>• To teach the curriculum</td>
</tr>
<tr>
<td>ISTJ</td>
<td>• Individual work</td>
<td>• To teach the curriculum</td>
</tr>
<tr>
<td></td>
<td>• Individual exploration</td>
<td>• Exploration of concepts</td>
</tr>
<tr>
<td>ISFP</td>
<td>• Individual work</td>
<td>• Review of basic skills</td>
</tr>
<tr>
<td></td>
<td>• Group investigations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Individual exploration</td>
<td></td>
</tr>
<tr>
<td>ITEM 6</td>
<td>ITEM 7</td>
<td>ITEM 12c</td>
</tr>
<tr>
<td>ITEM 12b</td>
<td>ITEM 12c</td>
<td>ITEM 12b</td>
</tr>
</tbody>
</table>
The two categorizations—this investigator's and the external researcher's—of the preferred classroom interactions and computer uses of the four selected teachers will be compared in what follows.

Table 34, 35, and 36 summarize the results of both categorizations of responses to items 6, 7, and 12c respectively which reflect the preferred classroom interactions of the four selected teachers. Table 37 summarizes the results of the preferred computer uses of these teachers.

**Table 34. Summary of Triangulation of Analysts for Item 6**

<table>
<thead>
<tr>
<th></th>
<th>External Researcher</th>
<th>This Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFP</td>
<td>• Individual work</td>
<td>• Individual work</td>
</tr>
<tr>
<td>INTP</td>
<td>• Individual work</td>
<td>• Individual work</td>
</tr>
<tr>
<td>ISTJ</td>
<td>• Individual work</td>
<td>• Individual work</td>
</tr>
<tr>
<td>ISFP</td>
<td>• Undetermined</td>
<td>• Individual work</td>
</tr>
</tbody>
</table>
Table 35. Summary of Triangulation of Analysts for Item 7

<table>
<thead>
<tr>
<th></th>
<th>External Researcher</th>
<th>This Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFP</td>
<td>• Individual</td>
<td>• Exploring on their own</td>
</tr>
<tr>
<td></td>
<td>exploration</td>
<td></td>
</tr>
<tr>
<td>INTP</td>
<td>• Individual</td>
<td>• Exploring on their own</td>
</tr>
<tr>
<td></td>
<td>exploration</td>
<td></td>
</tr>
<tr>
<td>ISTJ</td>
<td>• Individual</td>
<td>• Exploring on their own</td>
</tr>
<tr>
<td></td>
<td>exploration</td>
<td></td>
</tr>
<tr>
<td>ISFP</td>
<td>• Individual</td>
<td>• Exploring on their own</td>
</tr>
<tr>
<td></td>
<td>exploration</td>
<td></td>
</tr>
</tbody>
</table>

Table 36. Summary of Triangulation of Analysts for Item 12c.

Cooperative Learning vs. Individual Learning

<table>
<thead>
<tr>
<th>Preferences for Cooperative Learning and/or Individual Learning</th>
<th>External Researcher</th>
<th>This Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFP</td>
<td>• Individual work</td>
<td>• Individual Work</td>
</tr>
<tr>
<td></td>
<td>• Group work</td>
<td>• Cooperative Work</td>
</tr>
<tr>
<td></td>
<td>• Cooperative learning</td>
<td></td>
</tr>
<tr>
<td>INTP</td>
<td>• Group work</td>
<td>• Individual Work</td>
</tr>
<tr>
<td></td>
<td>• Cooperative exploration</td>
<td>• Cooperative Work</td>
</tr>
<tr>
<td></td>
<td>• Cooperative learning</td>
<td></td>
</tr>
<tr>
<td>ISTJ</td>
<td>• Individual work</td>
<td>• Individual Work</td>
</tr>
<tr>
<td>ISFP</td>
<td>• Individual work</td>
<td>• Individual Work</td>
</tr>
<tr>
<td></td>
<td>• Cooperative learning</td>
<td>• Group Discussion</td>
</tr>
</tbody>
</table>
**Table 37. Summary of Triangulation of Analysts for Item 12b**

<table>
<thead>
<tr>
<th>Role of Computers</th>
<th>External Researcher</th>
<th>This Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFP</td>
<td>To do calculations</td>
<td>Calculations</td>
</tr>
<tr>
<td>NTP</td>
<td>Exploration of concepts</td>
<td>To develop conjectures</td>
</tr>
<tr>
<td>ISTJ</td>
<td>To teach the curriculum</td>
<td>To teach the curriculum</td>
</tr>
<tr>
<td>ISFP</td>
<td>Review of basic skills</td>
<td>Review of Basic Skills</td>
</tr>
</tbody>
</table>

The categorization of the external researcher and this investigator coincide in great extension. The results of the triangulation of analysts verify the original categorization of the preferred classroom interactions and computer uses of the four selected teachers given by this investigator.

**Geometry Software Workshop Evaluation**

The participation in the workshop counted seven hours towards field experience for a methods class. It was necessary to develop a strategy to observe whether participants were interested in the use of computers in education and the credit hours or just in the credit hours, so the evaluation of the Geometry Software Workshop was used for this part of the study. The evaluation form includes two items offering extra information about the use of technology in mathematics education (see Figure 14).
Figure 14. Mathematics Software Workshop Announcement

Appendix I contains copies of the evaluation forms filled out by participants. The results of the workshop evaluation show that: (a) all Intuitive [N] types would like both to participate in another workshop, and to get more information about other workshops, (b) majority of Introvert–Sensing [IS] types would like to get more information about coming workshops, and (c) majority of Extrovert–Sensing [ES] types would not pursue in the learning of the use of computers in mathematics education.

Conclusion

The four selected preservice teachers plan to play different roles in a computer environment. The Intuitive–Feeling [NF], the Intuitive–Thinking [NT, and the Sensing–Feeling [SF] teachers may
play the role of facilitators. The Sensing-Thinking [ST] teacher may prefer a command style of teaching.

These four teachers plan to use the computers in different ways. The Intuitive-Feeling [NF] teacher wants students use computers for calculations. The Intuitive-Thinking [NT] teacher wants students use computers for exploration of geometrical relationships to generate conjectures. The Sensing-Thinking [ST] teacher wants to use computers to teach the curriculum. Finally, the Sensing-Feeling [SF] teacher wants to use computers to review basic skills.

The problem of integrating the use of computers in education requires a deep understanding of the current preferred methods of teaching and to explore how these preferences will mold the use of computers in education. The NCTM Curriculum and Evaluation Standards encourage discovery and cooperative learning in mathematics education. The results of the present study show that the Geometry Scenarios of the Geometry Project may provide a model to design computer environments in which some type of teachers—NF, NT, and SF—would teach mathematics in this way.

The Curriculum and Evaluation Standards encourage the use of technology in mathematics education in elementary and secondary school. In this respect, Plomp, and van de Wolde (1985) suggest that: "In reconsidering the curriculum, special attention must be
paid to questions relating to the emotional and social impact of several modes and rates of child-computer interaction" (p. 249).

The implications of the results for teacher education in the use of technology for mathematics education are discussed in Chapter 5. This last chapter also suggests to apply Jung’s Theory of Types to study other aspects related to teacher education and teacher change.
CHAPTER V

CONCLUSIONS AND IMPLICATIONS OF THE STUDY

At the present time, when our knowledge of material things is so great, and our understanding of ourselves so small, a true appreciation of the enormous unused potentialities of education is essential. The industrial revolution implies and requires a psychological revolution. Psychologically, we still belong to the era when people refused to believe that locomotives would run. (Sawyer, 1955, p. 9).

Sawyer's quotation implies that social changes require psychological accommodations. How will the increased speed of social changes affect new generations? Thornburg (1989) points out that "human development has been marked by periods, or ages, that have shaped the structure of our society. The agricultural age, for example, lasted about 6 000 years. It was followed by the industrial age which dominated society for only 300 years." (p. 106). He also observes that "the current age of information may dominate for only 30 years before it too is supplanted by still other ages" (p. 106). Previous generations lived in an apparently unchangeable world. "We and the children we teach do not have
this luxury. Instead we are being bombarded by increasingly rapid change until we reach the point where 'flux' will become the new flow" (p. 107). How will these accelerated changes affect people, and social structures?

Several authors have written about how information technologies will affect the goals and content of teaching and learning processes in schools and the forms these can take (Cohen, 1988; DiSessa, 1988; Malcom, 1988; Nickerson, 1988; Nickerson, and Zodhiates, 1988; Plomp, and van de Wolde, 1985). They have pointed out that handwriting, spelling, arithmetical computation, and memorization of facts are examples of basic subjects that may now be de-emphasized in favor of problem solving, information handling, experimentiation, and greater social interaction.

However, Carlson (1991) points out that the majority of teachers report that their teaching styles had not changed significantly with their use of computers; and Carleer, and Doornekamp (1990) have observed that the most important criterion that school teachers apply in the software selection is the fit of the courseware with the regular curriculum.

In light of the results of the present study as well as the theoretical framework developed in Chapter 2, some strategies for bringing teachers to the modernization of schools are suggested. This chapter will discuss, first, the results of the study and how they relate to the theoretical framework. Second, the implications
of the study for mathematics teacher education. Finally, some aspects of the process of incorporating technology in education that need more research are mentioned.

Discussion of Results

The results of the data analysis carried out to answer Research Questions 1, 2, and 3 will be summarized, first, and then the results of the data analysis will be discussed in light of the theoretical framework and the literature review included in Chapter 2.

Summary of Results

The results are based largely on four selected cases representing the four MBTI types of teachers, namely, the NF, NT, ST, and SF teachers.

Research Question 1. Among the 20 preservice teachers attending the geometry software demonstration there were nine different MBTI personality types. It was observed that 75 percent of participants were Sensing [S] types and that 50 percent were Introverts [N]. The proportion of the MBTI teachers in the geometry software demonstration was as follows: 20% of Intuitive–Feeling [NF] types, 5% of Intuitive–Thinking [NT] types, Sensing–Thinking [ST] types comprised the 40%, and the Sensing–Feeling [SF] types, the 35% of the group. There was the same number of Extrovert and Introvert students participating in the workshop demonstration.
The Geometry Software Workshop attracted a variety of types. The results of the evaluation of the Geometry Software Workshop suggest that the type of computer environment embedded in the geometry scenarios—designed by inservice high school teachers participating in the Geometry Project of St. Olaf College, Minnesota—may attract more personality types than the type of computer environment that the Computer Assisted Instruction favors which appeals mainly Introvert-Sensing types (Smith, 1971; White, and Smith, 1974, Hoffman, Waters, and Berry, 1981). However, this may not be the type of computer environment that appeals to Extrovert-Sensing types, who comprise the majority of the general population (about 75 percent).

**Research Question 2.** The results suggest that the teaching strategies, and evaluation methods that the four selected teachers plan to use when they teach high school geometry with the Geometer’s Sketchpad is very similar to that given by Silver, and Hanson (1985), that is, these teachers use always same teaching strategies and evaluation methods whether they teach with computers or not. Table 38 illustrates the categories of teaching strategies, teaching styles, and evaluation methods observed in this study.
<table>
<thead>
<tr>
<th></th>
<th>Teaching Strategies</th>
<th>Teaching Styles</th>
<th>Evaluation Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFP</td>
<td>• Creative problem solving</td>
<td>• Facilitator</td>
<td>• Observations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Flexibility of response</td>
</tr>
<tr>
<td>ITP</td>
<td>• Inquiry</td>
<td>• Facilitator</td>
<td>• Demonstration of abilities to apply, interpret, analyze</td>
</tr>
<tr>
<td></td>
<td>• concept formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISTJ</td>
<td>• Programmed instruction</td>
<td>• Instructional manager</td>
<td>• Close ended questions</td>
</tr>
<tr>
<td>ISFP</td>
<td>• Group investigation</td>
<td>• Facilitator</td>
<td>• Self reporting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Collection of unobtrusive data</td>
</tr>
</tbody>
</table>

On the one hand, the results of the data analysis suggest that the categorization of the *teaching strategies* and the *evaluation methods* that the four selected teachers—representing the four MBTI types of teachers: NF, NT, ST, and SF—plan to use when teaching high school geometry with the Geometer’s Sketchpad coincides with the categorization of preferred teaching strategies and evaluation methods of the four MBTI teachers observed by Silver, and Hanson (1985) in regular classes, with no use of technology. On the other hand, the results suggest that the categorization of teaching styles observed in this study differs from
that observed by Silver, and Hanson. The Intuitive-Feeling [NF] teacher, the Intuitive-Thinking [NT] teacher, and the Sensing-Feeling [SF] teacher reported in these notes would play the role of facilitators (see Table 24). However, the categorization of the preferred teaching style of the Sensing-Thinking [ST] teacher reported in these notes coincides with that given by Silver, and Hanson (see Table 24).

Research Question 3. The four selected teachers differ in the way they plan to use the Geometer's Sketchpad to teach high school geometry, and the type of classroom interactions that they would allow in their computer environments. Although the four teachers prefer to work in a computer laboratory because favors individual exploration of geometrical shapes, they plan to use the computers in different ways (see Table 39).
Table 39. Final Categorization of Classroom Interactions, and
Computer Uses

<table>
<thead>
<tr>
<th></th>
<th>Classroom Interactions</th>
<th>Computer Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFP</td>
<td>• Individual and cooperative learning</td>
<td>• To do calculations</td>
</tr>
<tr>
<td></td>
<td>• Exploring on their own</td>
<td></td>
</tr>
<tr>
<td>INTJ</td>
<td>• Individual and cooperative learning</td>
<td>• To develop conjectures</td>
</tr>
<tr>
<td></td>
<td>• Exploring on their own</td>
<td></td>
</tr>
<tr>
<td>ISTJ</td>
<td>• Individual learning</td>
<td>• To teach the curriculum</td>
</tr>
<tr>
<td></td>
<td>• Exploring on their own</td>
<td></td>
</tr>
<tr>
<td>ISFP</td>
<td>• Individual and cooperative learning</td>
<td>• To review basic skills</td>
</tr>
<tr>
<td></td>
<td>• Exploring on their own</td>
<td></td>
</tr>
</tbody>
</table>

Discussion

The discussion of the results will be related to teacher change.

The results of the present study support the results reported in
Story (1972), and Rudisill (1972), that is, the ST teacher is not
receptive to curricular changes. The categorization of teaching
strategies, and evaluation methods reported by Silver, and Hanson
(1985) may apply when teachers plan to use computers for teaching
geometry with the Geometer's Sketchpad. Though, the
categorization of teaching styles reported in this study does not follow the same pattern of Silver and Hanson's (see Table 26). Three of the four participating teachers may play the role of facilitators in a computer environment. These teachers—NF, NT, and SF—have a natural inclination for teaching mathematics in the way that is suggested by the National Council of Teachers of Mathematics in the *Curriculum and Evaluation Standards*. In particular, the preferred teaching styles and evaluation methods of the Intuitive-Thinking [NT] teacher would be more appropriate for implementing a school mathematics curriculum based on an inquiry approach (i.e., Socratic approach) and discovery.

Although it is interesting observing that there are teachers who may implement the NCTM *Evaluation and Curriculum Standards* with no difficulty, the discussion, however, will be focused on the Sensing-Thinking [ST] teacher, that is, the teacher who is not receptive to curricular changes.

**The adaptability system and teacher change.** On the one hand, MBTI studies suggest that teaching strategies, teaching styles, and evaluation methods may be related to personality types. On the other hand, Keirsey, and Bates (1978) have pointed out that "people are different from each other, and that no amount of getting after them is going to change them" (p. 2). If this is true, then the efforts for modifying the current practices of schoolteachers are meaningless.
The Sensing–Thinking teacher comprises the majority of school mathematics teachers. MBTI studies characterize this teacher as trainer, information giver, and instructional manager. His curriculum objectives emphasize basic skill, and acquisition of content. His learning environments emphasize purposeful work and organization and competition. His preferred instructional strategies emphasize behavior modification, drill and practice, convergent thinking tasks, demonstrations, and producing products. His teaching style may include programmed instruction, command style, mastery learning, and memorization. His evaluation procedures include objective tests, checklists, behavioral objectives, use of mechanical devices, demonstration of specific skills, and criterion referenced tests (Silver, and Hanson, 1985).

The preferred methods of teaching of the Intuitive–Feeling, Intuitive–Thinking, and Sensing–Feeling teachers are in tune with the teaching strategies that the Standards advocate. However, these teachers comprise a minority in the school mathematics teacher population, and have little influence. They cannot become promoters of curricular changes.

Majority of students are also Sensing students (75%) who "like and need structure and do best when lessons are presented sequentially in increments that make sense" (Keirsey, and Bates, 1978, p. 123). Keirsey, and Bates have observed that the Sensing–
Thinking student will attempt to do his best as long as "he receives clear directions so that he knows how to proceed with the task" (p. 123). Intuitive teachers tend to improvise and like open-ended activities which are not the favorites of Sensing-Thinking students. Intuitive teachers and intuitive students have to adapt their teaching and learning styles, respectively, to the school environment like it is defined today by Sensing-Thinking teachers and students.

Instead of trying to modify teachers' preferences for some methods of teaching, initiatives should be taken to modify school environments to make this profession appeals to more personality types. The school environment should allow diversity not just in terms of sociocultural aspects (ethnicity, socioeconomic status, and so on), or cognitive preferences (symbolic or visualizer, field dependent or field independent, and so on) but also in terms of teaching styles. MBTI studies have identified four types of teachers: Facilitators, inquirers, instructional managers, and nurturers. These teachers tend to focus on different aspects of learning and teaching, all of them equally valuable.

Human beings have a powerful adaptability system. This fact can be used to bring the school system to the process of change that science and technology impose to modern societies, though its mechanisms might not be completely understood. The school systems of modern societies need to adapt to the ever changing
requirements imposed by scientific and technological advances to maintain the current social development.

Between Perspectives

Prior to the present study, this investigator observed that some teachers adapted their teaching strategies easily to a computer environment that encourages discovery learning and free exploration while others felt very frustrated and uncomfortable working in this type of environment. Observing high school teachers working with geometry software led this investigator to explore whether personality factors were related to preferred teaching styles.

The original idea for developing a theoretical framework for the present study was to match affective and cognitive processes. The model of the adaptability system was developed with that purpose (Chapter 2, § 3). The adaptability system integrates the Jungian psychological functions and the stages involved in the Skemp's director system that he borrowed from cybernetics and which he uses to explain intelligent learning.

Along the present study, a new literature review was been carried out on how different perceptions of reality lead to different ways of conceptualizing the development of thought. This literature review is not reported here because it is not directly related to the original design of the present study. However, we can say that Davydov's (1972) discussion of different ways of
generalizing modified the original perspective and it suggests
different ways of integrating the theory of types to study *teaching*
and *learning* styles.

The analysis of the different types of generalization that the
four selected cases may favor when they plan to teach geometry
with the Geometer's Sketchpad was not included in the original
design of the study. However, the geometry activities of the four
selected cases suggest that Intuitive teachers may be interested in
developing the *theoretical thought* of their students, while the
activity of the Sensing teachers is more focused on developing the
*empirical thought* of their students. The following section tries to
relate the results of the MBTI studies reported in Chapter 2 with
other studies that have observed *teaching* and *learning styles* from
different perspectives.

Further Research

The need of modern societies for changing the paradigm of
teaching in schools has motivated the reevaluation of the logical
and epistemological principles of education. Davydov (1972)
provides a synthesis of this discussion and suggests a new set of
principles on which modern instruction should be based, if its goal
is the development of theoretical scientific thought.

Three aspects to be considered in the modernization of school
systems are discussed here: 1) The teacher-centered instruction; 2)
The relationship between the Intuitive function and theoretical
thought; and 3) Use of geometry software and ways of
genralization.

The Teacher-Centered Instruction

On the one hand, Cuban (1993), who after examining
elementary and high school instruction in urban and rural
schools, observed that teachers teach the entire class at the same
time; teacher talk dominates verbal expression during class time;
and classroom activities revolve around teacher questions and
explanations, student recitations, and the class' working on
textbook assignments. This author refers to this type of
instruction as "teacher-centered instruction" and points out that
"the basic instructional sequences and patterns in the core
academic subjects have remained teacher-centered since the turn
of the century" (p. 273). On the other hand, it has been observed
that Sensing types tend to be the majority in the school
population and that the proportion of Sensing teachers in
mathematics teacher population is even greater. As was
mentioned before, the Sensing-Thinking [ST] types would not be
immediately receptive to changes in curriculum or instructional
procedures (Story, 1972, p. 67).

The teacher characterization provided by MBTI studies may
help to explain school environments—the factors that participate
in their definition and permanence. Understanding schools as
they are now will help to develop strategies to design school
environments and education compatible with knowledge requirements of the Information Age.

The Sensing–Intuitive Scale Related to Cognitive Development

On the one hand, Davydov observes that under the current model of instruction, based on the empirical theory of thought, just a small number of children who have the 'gift' for generalizing at an abstract level will develop theoretical scientific thought. On the other hand, the MBTI studies focused on learning styles have arrived at the conclusion that those students who prefer the Intuitive function have a natural inclination for studying science and mathematics. Davydov suggests that:

It is important to try to have a more profound grasp of the internal preconditions [italics added] for the formation of the ordinary method of generalization in the majority of the other students. These studies, in time, will permit the design of a kind of instruction that, on the one hand, will actively develop in children the most productive types and levels of generalization and, on the other hand, will constantly depend on them in all the processes of organizing learning. (pp. 137–138)

This investigator proposes that those 'internal preconditions' to which Davydov makes reference may be related to the Sensing–
Intuitive scale of Jungian functions and that the MBTI is an instrument that may help to explore them. Two questions arise here: 1) Can all Intuitive students generalize at an abstract level? and 2) Do all students who can generalize at an abstract level prefer the Intuitive function?

Intuitive function and theoretical thought. Some MBTI studies suggest exploring the effect of the Intuitive–Sensing scale on the development of theoretical scientific thought in order to better understand what should be incorporated into instruction to help Sensing students develop their Intuitive function. For instance, DiTiberio (1983) proposes "to encourage some students to form a thesis from factual cues and to give support for their original ideas before we ask them for examples" (p. 5).

Geometry Software and Types of Generalizations

The methods of teaching of participating teachers could also be discussed in terms of the content of their geometry activities. The discussion here will be focused on the type of generalization that teachers may favor when teaching geometry with the Geometer's Sketchpad and the type of knowledge—empirical or theoretical—that they may facilitate with their activities. The activity of the Sensing teachers reflect that teachers may ask their students to carry out comparisons based on concrete–sensory data for the purpose of delineating general attributes and drawing up classifications or identifications.
Davidov observes that relying on the empirical theory of thought, educational psychology and didactics put emphasis on: 1) Comparison of the concrete-sensory data for the purpose of delineating the formally general attributes and drawing up a classification, and 2) the identification of concrete-sensory entities for the purpose of including them in a certain class. To carry out these tasks it is necessary to identify the essential characteristics of things or phenomena: "It is logical to suppose that 'essential' ones are constant, stable attributes that are retained in a given group of objects as the nonessential ones change" (Davidov, 1972, p. 15). The activities of the Sensing (ISFP and ISTJ) teachers described in this report reflect this model of cognitive development:

**ISFP:** The students will first construct a triangle on the computer. The angles and sides must be measured. The students should do this several times and compare the results of the measurements. I would like the students to use the results to analyze relationships between congruency and angle bisectors—if there are any.

**ISTJ:** The activity will help students become very knowledgeable with the formula $a^2 + b^2 = c^2$. This is possible because the students will see the results on the screen, and see that as you change the triangle the results are still the same.
Davidov has pointed out that this approach develops a one-sided generalization, that is, the route from the concrete to the abstract. However, the development of a scientific concept begins "with work on the concept itself as such, with a verbal definition, with operations that do not presuppose a spontaneous application of these concepts. . . . Here is a movement from the concept to the thing—from the abstract to the concrete" (Davydov, 1972, p. 184).

The improvement of instruction does not just depend on changing methods of teaching and evaluation procedures but it requires a reevaluation of the theory of cognitive development on which instruction and its methods and procedures are based. Davydov points out that:

Solving the essential problems in contemporary school education is ultimately linked to changing the type of thinking that is projected by the goals, content, and methods of instruction. The entire instructional system must be reoriented from children's development of rational-empirical thought to their development of modern theoretical scientific thought. (p. 369)

Davydov suggests six principles for designing an instruction that favors the development of theoretical thought. They are described in the last chapter of his book *Types of Generalization in*
**Instruction.** Here they are summarized as follows: (1) The concepts should not be given as ready-made knowledge; (2) Instruction should facilitate the development of the two types of thought—the empirical and the theoretical; (3) Students must use their empirical knowledge to develop mental models to study properties and relationships of abstract objects or phenomena.

This section has tried to orient the discussion on methods and procedures of education toward an evaluation of the logical and epistemological principles of instruction. The following sections will discuss the implications of the study for teacher education and software design.

**Implications of the Study**

The results of the study show that there is a type of teacher, the ST teacher, (also referred as SJ in the literature) who does not accept changes in curriculum and methods of teaching. MBTI studies report that this type of teacher comprises almost 50 percent of the schoolteacher population. There is a need to consider the learning characteristics of this type of teacher in the design of teacher education.

**Teacher Education**

This section discusses the implications of the study for mathematics teacher education. Considered first are the difference between Sensing and Intuitive types and their repercussion in student teachers. Next are the strategies to be incorporated in the
education of the Sensing teacher. Finally, the consequences of having Sensing teachers implementing the computer environments designed by Intuitive computer programmers are discussed.

**Sensing students of Intuitive teachers.** The MBTI characterization of college teachers and undergraduate students may help to develop teacher education programs that are more suitable for undergraduate teacher education students. Chapter 2 describes in more detail differences observed between Sensing and Intuitive teachers and Sensing and Intuitive students. As reported by Story (1972) college teachers are more likely to be Intuitive types and not appreciate Sensing characteristics very much. The following segment of the interview with a Sensing student reflects how some of his college teachers make him feel uncomfortable.

**ESTJ:** College professors label students here, I know. I have one now that has labeled me and . . . it's a good label but I have other professors that have labeled me and I don't like what I am labeled.

**Interviewer:** But what do teachers do that you feel you are labeled?

**ESTJ:** Their attitude towards me. Like if I raise my hand and I'll say this comment and they're like yeah, all right, yeah and then they'll go on. And like the other person will like come up and talk to them and they'll go on this like ten or fifteen–
minute explanation and they are saying the same thing over and over and over, and I'm like: that was very good. One was negative and the other was positive.

College teachers should become aware of their reactions toward Sensing students. The school environments that may help to develop the Sensing student's capabilities should be explored. The next section describes some strategies that can be incorporated in teacher education to help ST teachers to adapt to those changes that modern education will impose on schools.

**Sensing teachers and discovery learning.** The results of the present study suggest that the ST type of teacher may not adapt teaching strategies to a computer environment that encourages discovery and cooperative learning. Rather this type of teacher tends to adapt the use of the Geometer's Sketchpad to the curriculum and to his or her usual way of teaching. What are the teaching strategies that teacher education should incorporate to instruction to help teachers become part of the school system modernization?

Changing the current teacher-centered instruction requires more than teachers' access to computers for education. In a first approach to the use of technology in education, it is necessary that the use of computers matches the preferred method of teaching as it is explained in the following quotation:
Whether one will be successful in evoking a particular learning outcome depends on the whole pedagogical environment of which the computer system is only one element. If a teacher doesn't know how to induce and guide discovery processes in his pupils when there are no computers around, it is not very likely that he will be able to do so merely by introducing Logo in his lessons. He will probably end up teaching Logo just as he would teach BASIC, successively introducing new features of the language, whether or not they have any significance to his pupils by that time. In more traditional educational contexts it will be easier to implement tutor mode applications which match expository teaching strategies. (Plomp, and van de Wolde, 1985, p. 254).

Models of computer uses in education are needed to show teachers how they could incorporate this technology in their daily practice: "there are few models of how these devices [computers] can become a part of their instructional repertories" (Carlson, 1991, p. 3). Sensing teachers learn better if models of teaching are presented to them rather than explaining to them on a theoretical basis how cognitive strategies will improve students' learning. Story (1972) has observed that:
Type theory would also indicate that a Sensing-Judging [referred as ST in these notes] type would only change his pattern if he were able to observe a new pattern in actual operation. This implies that in-service training should involve participation on the part of the teachers in a workshop type of atmosphere. Any new equipment should be demonstrated, preferably with a live class in a relatively normal situation. If this procedure is not followed the sensing-judging type of teacher regularly concludes, "that's good in theory, but in practice, it won't work." (pp. 67-68)

Some participating preservice teachers answered that they would prefer methods classes that include an extensive use of technology, computers and calculators, and that they were oriented toward exploring pedagogical capabilities of these technologies rather than programming courses when they were asked: Do you think that programming courses would help preservice teachers feel more comfortable?

Case 2. ISTJ: I don't know... For someone who's already comfortable with computers, programming will help to feel more comfortable but for someone who doesn't have experience at all they usually end up coming out of programming classes. They hate it and they don't want to see more computers again.
Mandler (1989) points out that "both affect and learning are characteristics of contemporary mankind. As psychologists, we wish to understand them, and, whenever possible, modify and make adjustments to them in order to improve the human condition" (p. 17). The most important element in any computer environment is the human factor. The underlying phenomenon of interest in this study is to find out a way to bring teachers to the change that school systems of modern societies require. To define new roles for teachers in computer environments, it is necessary to explore how computers will modify current ways of teaching and, vice versa, how the preferences for teaching styles of teachers will determine the computer uses in educational settings.

**Computers in Education**

The models of computer use in mathematics education come from outside the school system (Dreyfus, 1972; O'Shea, and Self, 1983; Papert, 1980; Solomon, 1987; Taylor, 1980). These models of computer environments for mathematics education have suggested new roles for teachers. These models also suggest how students should interact with computers and what teachers have to do to facilitate learning. First designs of computer environments have tried to implement models of education which have not matched teachers' values and beliefs. What teachers think about the role that computers should play in mathematics education and how
they plan to integrate the use of technology in education needs to be considered in the design of educational software and computer environments. It is also convenient to observe the pedagogical potential and limitations that different computer environments may impose when designed with different types of software as Dreyfus, and Dreyfus (1984) observed about the use of Computer-Assisted Instruction (CAI): "If, however, one insists on generalizing the CAI method and its success in teaching beginners to higher levels of skill acquisition, we then get an educational horror story" (p. 597).

All the decisions that participating preservice teachers made in designing their computer environments, and in selecting the teaching strategies which in their view facilitate learning are "cognitive evaluations" as referred by Mandler (1989) (Chapter 2, §1). How are the preferred Jungian functions related to the construction of value systems? MBTI studies suggest that people with similar types share the same system of values; so they respond similarly to similar situations. The studies reported in Chapter 2 reveal that teachers and programmers do not share the same system of values. This difference between the value systems of computer experts and school teachers may explain the gap between the models of computer uses in education and the way that schoolteachers implement them into their classes.
Carleer, and Doornekamp (1990) conclude that "to realize a valuable integration of computers in education, it will be necessary to focus the discussion no longer on computers, but on how to think and make decisions with the improvement of education as the goal" (p. 5).

Conclusions

"I can't provide for all needs. For example, some kids need quiet. I have guilt at not meeting all their needs. Maybe different delivery systems help reach different learners." (Quoted in Carlson, 1991, p. 7).

According to Patton (1980), qualitative methods may "provide perspective . . . theories of action, . . . and context-bound information" (pp. 282–283). The present study suggests approaching the old problem of "teacher change" from a new perspective, that is, the development of school environments that allow the adaptation of diverse methods of teaching so students will have more opportunities to develop their natural capabilities. The implementation of technologies of the Information Age may facilitate this process and, in light of the results of the present study, the following considerations on computer environment design, software design, and teacher education may help to reach this goal.

School computer environments. Among the components that seem to be important to consider in the design of computer environments are: (a) access to software with different structural
design, (b) the students' interactions in both individual and group work, (c) activities that favor the development of empirical and theoretical thought, and (d) the evaluation that focuses on analysis, discovery and verification procedures rather than answers to close-ended questions.

**Educational software.** The design of educational software should be flexible enough to facilitate the teacher's task of creating activities that favor the development of both empirical and theoretical thought.

**Teacher education.** Teacher education should prepare student teachers to teach school mathematics with computers. It seems necessary to develop teaching strategies that help Sensing teachers to adapt to a school environment that favors discovery and cooperative learning and to the dynamic of change that successive developments in science and technology will impose on the school system.

In summary, it is necessary to identify specific characteristics of preservice teachers to design and provide instruction that enhances their natural teaching skills and favors their creativity and personal expression. To do so, we should explore computer environments that help teachers do their best as both persons and professionals and that give all students an equal chance at success when learning geometry with computers.
APPENDIX A

BIBLIOGRAPHICAL MATERIALS REQUESTED TO CENTER FOR
APPLICATIONS OF PSYCHOLOGICAL TYPE
April 8, 1994

Herendira Garcia Tello
2379 S. Worthington Lane
Bloomington, IN  47401

Dear Miss Garcia:

Please forgive the delay in answering your request.

The reference for the article you asked about is:


The volume number is not in the copy we have. The article is in a section called "Research on College Science Teaching."

You have my permission to use Figure 1 on page 115. I am sending you a copy of "Understanding the Type Table" that has the same figure. We use it to explain type basics.

I am also sending a copy of two lists from the MBTI Bibliography. One was for a search on "math" and the other on McCaulley. I have checked a few items that may interest you. CAPT can make copies of some materials from the Isabel Briggs Myers Memorial Library for a nominal cost. Our Research Consulting Department can help researchers. In fact we are having a workshop here on MBTI research July 21-22. I am enclosing our training brochure.

I am sending you a catalog and have checked some items of interest.

When you complete your dissertation, I do hope you will donate a copy to the Isabel Briggs Myers Memorial Library here at CAPT. We shall of course add your work to the MBTI Bibliography.

Very best wishes for success in completing your dissertation.

Sincerely,

Mary H. McCaulley, Ph.D.
President

Enclosures
APPENDIX B

PERSONALITY TYPE DESCRIPTION
UNDERSTANDING THE TYPE TABLE

#### First Preferences Based on Inflection at a Person's Type

**Does the person's interest flow mainly to...**

<table>
<thead>
<tr>
<th>E</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>The outer world of actions, objects and persons?</td>
<td>The inner world of concepts and ideas?</td>
</tr>
</tbody>
</table>

**Extraversion** | **Introversion**

**Does the person prefer to perceive...**

<table>
<thead>
<tr>
<th>S</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>The immediate, real, practical facts of experience and life?</td>
<td>The possibilities, relationships and meanings of experience?</td>
</tr>
</tbody>
</table>

**Sensing** | **Intuition**

**Does the person prefer to make judgments or decisions...**

<table>
<thead>
<tr>
<th>T</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectively, impersonally, considering causes of events and where decisions may lead?</td>
<td>Subjectively and personally, weighing values of choices and how they matter to others?</td>
</tr>
</tbody>
</table>

**Thinking** | **Feeling**

**Does the person prefer mostly to live...**

<table>
<thead>
<tr>
<th>J</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>In a decisive, planned and orderly way, aiming to regulate and control events?</td>
<td>In a spontaneous, flexible way, aiming to understand life and adapt to it?</td>
</tr>
</tbody>
</table>

**Judgment** | **Perception**

---

**MYERS-BRIGGS Type Indicator and MBTI are registered trademarks of Consulting Psychologists Press Inc., Palo Alto, CA**

**Center for Applications of Psychological Type, Gainesville, Florida**

1-800-777-2278
UNDERSTANDING THE TYPE TABLE

The Myers-Briggs Type Inventory (MBTI) is a personality assessment tool that categorizes individuals into one of 16 types based on four dimensions: Introversion/Extraversion (I/E), Sensing/Intuition (S/N), Thinking/Feeling (T/F), and Judging/Perceiving (J/P). Each individual's type is represented by a four-letter abbreviation, with the first two letters indicating the preference for the primary function and the last two letters indicating the preference for the secondary function.

### The 16 Types

<table>
<thead>
<tr>
<th>ST</th>
<th>SF</th>
<th>SP</th>
<th>SN</th>
<th>SP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intuitive</strong></td>
<td><strong>Intuitive</strong></td>
<td><strong>Intuitive</strong></td>
<td><strong>Intuitive</strong></td>
<td><strong>Intuitive</strong></td>
</tr>
<tr>
<td><em>Sensing</em></td>
<td><em>Sensing</em></td>
<td><em>Sensing</em></td>
<td><em>Sensing</em></td>
<td><em>Sensing</em></td>
</tr>
<tr>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
<td><em>Sensing</em></td>
<td><em>Feeling</em></td>
<td><em>Sensing</em></td>
</tr>
<tr>
<td><em>Introverted</em></td>
<td><em>Introverted</em></td>
<td><em>Introverted</em></td>
<td><em>Introverted</em></td>
<td><em>Introverted</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NT</th>
<th>NF</th>
<th>NP</th>
<th>NF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intuitive</strong></td>
<td><strong>Thinking</strong></td>
<td><strong>Extraverted</strong></td>
<td><strong>Extraverted</strong></td>
</tr>
<tr>
<td><em>Sensing</em></td>
<td><em>Feeling</em></td>
<td><em>Sensing</em></td>
<td><em>Sensing</em></td>
</tr>
<tr>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
<td><em>Sensing</em></td>
<td><em>Feeling</em></td>
</tr>
<tr>
<td><em>Introverted</em></td>
<td><em>Introverted</em></td>
<td><em>Introverted</em></td>
<td><em>Introverted</em></td>
</tr>
</tbody>
</table>

### The 4 Color Types

<table>
<thead>
<tr>
<th><strong>Intuitive</strong></th>
<th><strong>Sensing</strong></th>
<th><strong>Thinking</strong></th>
<th><strong>Feeling</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Intuitive</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
</tr>
<tr>
<td><em>Intuitive</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
</tr>
<tr>
<td><em>Intuitive</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
</tr>
<tr>
<td><em>Intuitive</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
</tr>
</tbody>
</table>

### The 4 Cognitive Functions

<table>
<thead>
<tr>
<th><strong>Intuition</strong></th>
<th><strong>Feeling</strong></th>
<th><strong>Sensing</strong></th>
<th><strong>Thinking</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Intuition</em></td>
<td><em>Feeling</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
</tr>
<tr>
<td><em>Intuition</em></td>
<td><em>Feeling</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
</tr>
<tr>
<td><em>Intuition</em></td>
<td><em>Feeling</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
</tr>
<tr>
<td><em>Intuition</em></td>
<td><em>Feeling</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
</tr>
</tbody>
</table>

### The 4 Attitude Combinations

<table>
<thead>
<tr>
<th><strong>Intuitive</strong></th>
<th><strong>Sensing</strong></th>
<th><strong>Thinking</strong></th>
<th><strong>Feeling</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Intuition</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
</tr>
<tr>
<td><em>Intuition</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
</tr>
<tr>
<td><em>Intuition</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
</tr>
<tr>
<td><em>Intuition</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
</tr>
</tbody>
</table>

### The 4 Decision-Making Combinations

<table>
<thead>
<tr>
<th><strong>Intuition</strong></th>
<th><strong>Sensing</strong></th>
<th><strong>Thinking</strong></th>
<th><strong>Feeling</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Intuition</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
</tr>
<tr>
<td><em>Intuition</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
</tr>
<tr>
<td><em>Intuition</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
</tr>
<tr>
<td><em>Intuition</em></td>
<td><em>Sensing</em></td>
<td><em>Thinking</em></td>
<td><em>Feeling</em></td>
</tr>
</tbody>
</table>

### Notes

- For a more detailed explanation and examples of each type, refer to the source: "Understanding the Type Table."
### Sensing Types

<table>
<thead>
<tr>
<th>ISTJ</th>
<th>ISFJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing, quiet, close contact, practical. Orderliness, work efficiently. Logical, realistic, and dependable. Emphasis on organization. Takes responsibility. Makes up their own minds on what should be accomplished and works logically. Neatly, regardless of opinions or distractions.</td>
<td></td>
</tr>
<tr>
<td>Quiet, thoughtful, reserve, and conscientious. Work efficiently and meet deadlines. Logical, realistic, and dependable. Emphasis on organization. Takes responsibility. Makes up their own minds on what should be accomplished and works logically. Neatly, regardless of opinions or distractions.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ISTP</th>
<th>ISFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classy, on-the-spot problem solving. Do not worry about what is going to come along. Focus on the present and the future. Likes to be practical and concrete, often overlooking the big picture.</td>
<td></td>
</tr>
<tr>
<td>Feeling, quietly friendly, sensitive, kind, motherly. They like harmony. They are sensitive to others' feelings and are sensitive to others' needs. They often ignore their own needs.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESTP</th>
<th>ESFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical, hands-on, creative, and energetic. They like to be practical and concrete, often overlooking the big picture.</td>
<td></td>
</tr>
<tr>
<td>outgoing, easygoing, loving, friendly, and enthusiastic. They enjoy harmony. They are sensitive to others' feelings and are sensitive to others' needs. They often ignore their own needs.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESTJ</th>
<th>ESFJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical, hands-on, creative, and energetic. They like to be practical and concrete, often overlooking the big picture.</td>
<td></td>
</tr>
<tr>
<td>Warm-hearted, outgoing, people-oriented, and helpful. They enjoy harmony. They are sensitive to others' feelings and are sensitive to others' needs. They often ignore their own needs.</td>
<td></td>
</tr>
<tr>
<td>INTJ</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>Usually have original minds and great drive for their own ideas and purposes. They are perceptive, able to see far ahead, and may appear aloof. They can be impatient with those who do not share their views. They are often visionaries, and may seem unrealistic to others. They are independent thinkers and often have a strong sense of justice. They are often leaders.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INTJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usually have original minds and great drive for their own ideas and purposes. Their thinking is often abstract and imaginative, and they may seem to be living in their own world. They are often visionaries, and may seem unrealistic to others. They are often leaders.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiet and reserved. Especially enjoy theoretical or scientific pursuits. They love solving problems with logic and analysis. They are usually interested in ideas, with little liking for parties or small talk. They tend to have sharply defined interests. Need careers where some strong interest can be used and useful.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ENFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warmly enthusiastic, high spirited, ingenious, imaginative. Able to do almost anything that interests them. Quick with a solution for any problem. Usually rely on their ability to improvise instead of preparing in advance. Can usually find compelling reasons for whatever they want.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ENTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quick, ingenious, good at many things. Stimulating company, wise and outspoken. May argue for fun on either side of a question. Reluctant to solve new and challenging problems, but may neglect routine assignments. Will turn to one new interest after another. Skillful in finding logical reasons for what they want.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ENFJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsive and responsible. Generally feel real concern for what others think or want, and try to help others get along with each other, especially when questions are asked. Can present a proposal in a subtle, persuasive manner. Will not be easily dissuaded from a decision. Usually well informed and witty. Adding to their fund of knowledge is in itself more pleasant and comforting than their experience in an授權 context.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ENTJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helpful, decisive, leaders in activities. Usually good at anything that requires reasoning and intelligent talk, such as public speaking. Are usually well informed and witty. Adding to their fund of knowledge is in itself more pleasant and comforting than their experience in an授权 context.</td>
</tr>
</tbody>
</table>
APPENDIX C

MBTI FORM G REPORTED RELIABILITY
<table>
<thead>
<tr>
<th>Total Form G data bank</th>
<th>G</th>
<th>M/F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>32,711</td>
<td>82</td>
</tr>
<tr>
<td>Female</td>
<td>84</td>
<td>83</td>
</tr>
<tr>
<td>Total</td>
<td>10,944</td>
<td>64</td>
</tr>
<tr>
<td>Traditional junior high school student</td>
<td>232</td>
<td>79</td>
</tr>
<tr>
<td>Traditional senior high school student</td>
<td>106</td>
<td>84</td>
</tr>
<tr>
<td>Adult high school dropout</td>
<td>77</td>
<td>60</td>
</tr>
<tr>
<td>Adult high school graduate</td>
<td>1,040</td>
<td>82</td>
</tr>
<tr>
<td>Traditional college student</td>
<td>1,598</td>
<td>82</td>
</tr>
<tr>
<td>Nontraditional college student</td>
<td>3,704</td>
<td>63</td>
</tr>
<tr>
<td>Adult college graduate</td>
<td>9,094</td>
<td>63</td>
</tr>
<tr>
<td>Age Conscience</td>
<td>72</td>
<td>78</td>
</tr>
<tr>
<td>12-17</td>
<td>64</td>
<td>69</td>
</tr>
<tr>
<td>18-20</td>
<td>55</td>
<td>60</td>
</tr>
<tr>
<td>21-24</td>
<td>91</td>
<td>61</td>
</tr>
<tr>
<td>25-29</td>
<td>82</td>
<td>67</td>
</tr>
<tr>
<td>30-39</td>
<td>83</td>
<td>66</td>
</tr>
<tr>
<td>40-49</td>
<td>73</td>
<td>69</td>
</tr>
<tr>
<td>50-59</td>
<td>103</td>
<td>80</td>
</tr>
<tr>
<td>60+</td>
<td>92</td>
<td>86</td>
</tr>
<tr>
<td>From F sample Table 16 of each Type</td>
<td>92</td>
<td>84</td>
</tr>
</tbody>
</table>

Table 10.6. Test-related/nodule-response functions of continued table of contents.

<table>
<thead>
<tr>
<th>Description of Sample</th>
<th>Form Interval</th>
<th>N</th>
<th>Sex</th>
<th>E</th>
<th>SN</th>
<th>SF</th>
<th>JP</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Seventh grade students</td>
<td>F 12 months</td>
<td>77</td>
<td>M/F</td>
<td>73</td>
<td>69</td>
<td>66</td>
<td>69</td>
</tr>
<tr>
<td>(2) Senior Citizens of 1963</td>
<td>F 16-18 months</td>
<td>128</td>
<td>M</td>
<td>75</td>
<td>69</td>
<td>62</td>
<td>74</td>
</tr>
<tr>
<td>(3) Vermont's Class of 1963</td>
<td>F 1 month</td>
<td>90</td>
<td>M/F</td>
<td>82</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>(4) Harvard undergraduate</td>
<td>F 2 months</td>
<td>146</td>
<td>M</td>
<td>80</td>
<td>69</td>
<td>68</td>
<td>68</td>
</tr>
<tr>
<td>(5) Western undergraduate</td>
<td>F 2 months</td>
<td>191</td>
<td>M</td>
<td>83</td>
<td>69</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>(6) Massachusetts State University</td>
<td>F 1 week</td>
<td>92</td>
<td>M/F</td>
<td>89</td>
<td>68</td>
<td>66</td>
<td>88</td>
</tr>
</tbody>
</table>

Table 10.5. Test-related/nodule-response functions of continued table of contents.

<table>
<thead>
<tr>
<th>Description of Sample</th>
<th>Form Interval</th>
<th>N</th>
<th>Sex</th>
<th>E</th>
<th>SN</th>
<th>SF</th>
<th>JP</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) 1977 Form A study</td>
<td>F 1 week</td>
<td>94</td>
<td>M</td>
<td>79</td>
<td>70</td>
<td>56</td>
<td>76</td>
</tr>
<tr>
<td>(2) 1977 Form B study</td>
<td>F 1 week</td>
<td>73</td>
<td>M</td>
<td>70</td>
<td>75</td>
<td>62</td>
<td>97</td>
</tr>
<tr>
<td>(3) 1977 Form C study</td>
<td>F 1 week</td>
<td>72</td>
<td>M</td>
<td>77</td>
<td>64</td>
<td>48</td>
<td>63</td>
</tr>
<tr>
<td>(4) 1977 Form D study</td>
<td>F 1 week</td>
<td>73</td>
<td>M</td>
<td>77</td>
<td>70</td>
<td>67</td>
<td>80</td>
</tr>
<tr>
<td>(5) 1977 Form E study</td>
<td>F 1 week</td>
<td>76</td>
<td>M</td>
<td>77</td>
<td>75</td>
<td>61</td>
<td>97</td>
</tr>
<tr>
<td>(6) 1977 Form F study</td>
<td>F 1 week</td>
<td>75</td>
<td>M</td>
<td>76</td>
<td>85</td>
<td>61</td>
<td>84</td>
</tr>
<tr>
<td>(7) Oxford University</td>
<td>4 weeks</td>
<td>111</td>
<td>M/F</td>
<td>82</td>
<td>67</td>
<td>78</td>
<td>91</td>
</tr>
<tr>
<td>(8) Stanford University</td>
<td>4 weeks</td>
<td>29</td>
<td>M/F</td>
<td>62</td>
<td>60</td>
<td>77</td>
<td>77</td>
</tr>
<tr>
<td>(9) Harvard University</td>
<td>4 weeks</td>
<td>40</td>
<td>M/F</td>
<td>76</td>
<td>85</td>
<td>71</td>
<td>84</td>
</tr>
<tr>
<td>(10) MIT</td>
<td>4 weeks</td>
<td>40</td>
<td>M/F</td>
<td>80</td>
<td>61</td>
<td>93</td>
<td>61</td>
</tr>
<tr>
<td>(11) MIT</td>
<td>4 weeks</td>
<td>40</td>
<td>M/F</td>
<td>80</td>
<td>61</td>
<td>93</td>
<td>61</td>
</tr>
</tbody>
</table>

Notes: Definition table contains correlations.

Sources and distributions of data appear in Appendix B.

APPENDIX D

SILVER, AND HANSON'S TEACHER CHARACTERIZATION
### Teaching and Learning Behaviors by Styles

*By Harvey Silver and Robert Hanson*

<table>
<thead>
<tr>
<th>Teachers May Be Characterized As</th>
<th>Learners May Be Characterized As</th>
<th>Curriculum Objectives Emphasize</th>
<th>Learning Environments Emphasize</th>
<th>Instructional Strategies Emphasize</th>
<th>Teaching Strategies Include</th>
<th>Evaluation Procedures Include</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST</td>
<td>Trainers, Information Givers, Instructional Managers</td>
<td>Realistic, Practical, Matter of Fact</td>
<td>Basic Skills, Acquisition of Content</td>
<td>Purposeful Work, Organization and Competition</td>
<td>Behavior Modification, Practice and Drills, Convergent Thinking Tasks, Demonstrations, Producing Products</td>
<td>Objective tests, Checklists, Behavioral Objectives, Use of Mechanical Devices, Demonstrations of Specific skills, Criterion-Referenced Tests</td>
</tr>
<tr>
<td>NT</td>
<td>Intellectual Challengers, Inquirers, Theorists</td>
<td>Logical, Intellectual, Knowledge Oriented</td>
<td>Critical Thinking, Concept Development</td>
<td>Discovery, Inquiry and Independence</td>
<td>Information Processing, Research, Inductive Reasoning, Written Reports, Problem-Solving</td>
<td>Open-Ended Questions, Essays, Demonstration of Abilities to Apply, Synthesize, Interpret, Integrate, Analyze, Evaluate, Think Divergently</td>
</tr>
</tbody>
</table>
GEOMETRY SOFTWARE WORKSHOP

TAKE A LOOK OF THE USE OF TECHNOLOGY IN THE GEOMETRY CLASSROOM
Elise Galindo 359-1914

WHO: Students enrolled in the M457 Methods of Teaching Secondary School Mathematics.
WHERE: Education 205.
WHEN: See schedule below.
WHAT: The Geometry Software Workshop (GSW) includes: 1) a demonstration of three Geometric Supposer and Geometer's Sketchpad, 2) discussion of preferred method of teaching according to personality type, and 3) samples of activities to teach high school geometry with geometry software.

GEOMETRY SOFTWARE WORKSHOP DESCRIPTION:
The GSW gives 7 hours towards field experience M403 associated with M457 Methods of Teaching Secondary School Mathematics. The GSW includes the following:
1) Reading of a short article on some commonly accepted myths about the use of computers in geometry classes (15 minutes).
2) Responding the Myers-Briggs Type Indicator instrument to determine personality types (1/2 hour).
3) Triangles with Geometric Supposer and Geometer's Sketchpad (1 hour).
4) Quadrilaterals with Geometric Supposer and Geometer's Sketchpad (1 hour).
5) Circles with Geometric Supposer and Geometer's Sketchpad (1 hour).
6) Design of a geometry activity (no less than one page and no more than three pages) integrating one of the software packages.
7) Collection of students' geometry activities.
8) Discussion of your geometry activity with Elise Galindo (1/2 hour).

GEOMETRY SOFTWARE WORKSHOP SCHEDULE:

<table>
<thead>
<tr>
<th>DATE</th>
<th>LOCATION</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Oct. 4</td>
<td>Educ 3125</td>
</tr>
<tr>
<td>3</td>
<td>Oct. 11 or Oct. 14</td>
<td>Educ 2025</td>
</tr>
<tr>
<td>4</td>
<td>Oct. 18 or Oct. 21</td>
<td>Educ 2025</td>
</tr>
<tr>
<td>5</td>
<td>Oct. 25 or Oct. 28</td>
<td>Educ 2025</td>
</tr>
<tr>
<td>6</td>
<td>Nov. 1 to Nov. 5</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Nov. 8</td>
<td>Educ 1210</td>
</tr>
<tr>
<td>8</td>
<td>Nov. 15 to Nov. 19</td>
<td>Room 3220</td>
</tr>
</tbody>
</table>

Note: (1) Following session 6, an appointment at your convenience will be established to review your geometry activity. (2) All participating students will receive a package with all collected activities.
GEOMETRY SOFTWARE WORKSHOP
SIGN FORM

Name: ____________________________ Date: ________

TO PARTICIPATE IN THE GEOMETRY SOFTWARE WORKSHOP YOU NEED TO SELECT DATES WHEN YOU WILL ATTEND SESSIONS 3, 4, AND 5. PLEASE MARK YOUR THREE DATE CHOICES WITH A √.

<table>
<thead>
<tr>
<th>Software Demonstration</th>
<th>Oct. 11</th>
<th>Oct. 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 4</td>
<td>Oct. 18</td>
<td>Oct. 21</td>
</tr>
<tr>
<td>Session 5</td>
<td>Oct. 25</td>
<td>Oct. 28</td>
</tr>
</tbody>
</table>

-----------------------------

IF YOU NEED ASSISTANCE IN THE DESIGN OF THE GEOMETRY ACTIVITY, THE INSTRUCTOR OF THE WORKSHOP WILL BE AVAILABLE IN ROOM 3220 AS FOLLOWS:

Nov. 1 8:00 a.m. to 9:00 a.m. 11:00 a.m. to noon
Nov. 2 10:00 a.m. to noon  2:00 p.m. to 4:00 p.m.
Nov. 3 8:00 a.m. to 9:00 a.m. 11:00 a.m. to noon
Nov. 4 10:00 a.m. to noon  2:00 p.m. to 4:00 p.m.
Nov. 5 10:00 a.m. to noon  2:00 p.m. to 4:00 p.m.

OTHER TIMES BY APPOINTMENT
Ellie Galindo
Home: 339–1914
Office: 856–8185
September 29, 1993

Dear (name):

Your participation in this study is very important. Thanks to students like you, who find time to participate in research studies, we may increase our knowledge on the use of technology in education. I will do my best for making this experience enjoyable and interesting for you. I expect you to attend all sessions, do your geometry activity, and discuss your geometry activity with me. I will give you a list of points you may consider for the design of your geometry activity.

Remember, your schedule is as follows:

<table>
<thead>
<tr>
<th>Date,</th>
<th>Location</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday, Oct 4</td>
<td>Educ 3125</td>
<td>8:30 a.m. to 9:00 a.m.</td>
</tr>
<tr>
<td>Monday, Oct 11</td>
<td>Educ 2025</td>
<td>7:00 p.m. to 8:00 p.m.</td>
</tr>
<tr>
<td>Monday, Oct 18</td>
<td>Educ 2025</td>
<td>7:00 p.m. to 8:00 p.m.</td>
</tr>
<tr>
<td>Monday, Oct 25</td>
<td>Educ 2025</td>
<td>7:00 p.m. to 8:00 p.m.</td>
</tr>
</tbody>
</table>

You will want to allocate about 2 hours to design your geometry activity during the week of November 1 to November 5. If you need assistance, I will be in room 3220 at the following schedule.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov. 1</td>
<td>8:00 a.m. to 9:00 a.m.</td>
</tr>
<tr>
<td>Nov. 2</td>
<td>10:00 a.m. to noon</td>
</tr>
<tr>
<td>Nov. 3</td>
<td>8:00 a.m. to 9:00 a.m.</td>
</tr>
<tr>
<td>Nov. 4</td>
<td>10:00 a.m. to noon</td>
</tr>
<tr>
<td>Nov. 5</td>
<td>10:00 a.m. to noon</td>
</tr>
</tbody>
</table>

If you need to make an appointment call 859-8185. I look forward to sharing this experience with you.

Sincerely,

Ellie Galindo
APPENDIX F

MYERS–BRIGGS TYPE INDICATOR FORM G
Directions

There are no “right” or “wrong” answers to these questions. Your answers will help show how you like to look at things and how you like to go about deciding things. Knowing your own preferences and learning about other people’s can help you understand where your special strengths are, what kinds of work you might enjoy, and how people with different preferences can relate to each other and be valuable to society.

Read each question carefully and mark your answer on the separate answer booklet. Make no marks on this question booklet. Do not think too long about any question. If you cannot decide how to answer a question, skip it and return to it later.

When reading the questions, be sure to follow the question numbers and work ACROSS the page from left to right. When you mark your answers on the separate answer booklet, you will also work across the page.

There are two parts to this question booklet. Part I is above the shaded line; the instructions for this part are at the top of the page. Part II is below the shaded line; the instructions for this part are at the bottom of the page. Be sure to read and follow the separate directions for each part.

Read the directions on the front of the answer booklet. After reading each question, mark your answer by making an “X” in the appropriate box.

When you finish answering all the questions, read the directions at the bottom of your answer booklet for how to score your MBTI® test. Be sure to turn in your question booklet when you have finished with it.
APPENDIX G

GEOMETRY PROJECT SCENARIOS
Introduction to the Geometry Software Workshop Booklets

The geometry activities included in this booklet were designed to fit the high-school geometry curriculum, to complement the geometry textbook, and to be taught with the Geometer's Sketchpad. The goal of this booklet is twofold: (a) to help you to get started with the software, and (b) to encourage you to experience discovery learning. The commands needed to get into the activity have been listed so you will learn the software at the same time that you explore geometrical relationships.

Some activities were designed by inservice high school geometry teachers, members of the Geometry Project of the St. Olaf College at Minnesota. Martha Wallace, the chair of the project, has promoted the use of computers in the teaching of high school geometry—organizing conferences and workshops for high school teachers, and creating models for teaching geometry with the aid of geometry software—for more than four years.

The Geometry Project encourages inservice high school geometry teachers to become active and creative part of the project. Forty-three teachers have participated in the Geometry Project. They have designed geometry scenarios that include about 200 geometry activities on several topics (triangles, quadrilaterals, circles, polygons, transformations, similarity, etc.) to be taught with the Geometer's Sketchpad or the Geometric Supposer. If you are interested in getting more information about the Geometry Project, please write or call to:

Martha Wallace  Phone: (507)646-3408  
St. Olaf College  Fax: (507)646-3104  
1520 St Olaf Ave.  Email: wallace@stolaf.edu  
Northfield, MN  55057
## Scenario List
### Computers in Geometry Classrooms

<table>
<thead>
<tr>
<th>Title (length in days)</th>
<th>Author</th>
<th>Course Text</th>
<th>Hard/Software</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Angles:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>angles, definitions, and relations</td>
<td></td>
<td>ch.2 &amp; 3</td>
<td></td>
</tr>
<tr>
<td><strong>Applications:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Geometry Applications</td>
<td>Banks</td>
<td>UCSMP</td>
<td>M:Sketch</td>
</tr>
<tr>
<td><strong>Area:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Area of Polygons (20)</td>
<td>Harley</td>
<td>Jurgensen (HM)</td>
<td>A:Sup-C,Q,T</td>
</tr>
<tr>
<td>determination from examples</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Area of Plane Figures (14)</td>
<td>Johnson</td>
<td>UCSMP, ch.8</td>
<td>M:Sketch</td>
</tr>
<tr>
<td>includes perimeters &amp; tessell.</td>
<td></td>
<td>ch. 8</td>
<td></td>
</tr>
<tr>
<td>5. Scenario on Area (13)</td>
<td>Lagarde</td>
<td>Saxon</td>
<td>M:Sketch</td>
</tr>
<tr>
<td>includes surface area, volume</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Teaching an Area Unit (16)</td>
<td>Miller</td>
<td>Holt, ch. 12</td>
<td>A:Presup, Sup-T</td>
</tr>
<tr>
<td>7. Areas of Polygons (10)</td>
<td>Sampson</td>
<td>Jurgensen (HM)</td>
<td>M:Sketch</td>
</tr>
<tr>
<td><strong>Circles:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Conjecturing with Circles (14)</td>
<td>Belanger</td>
<td>Jurgensen (HM)</td>
<td>P:Sup-C</td>
</tr>
<tr>
<td>angles, arcs, chords, secants, etc.</td>
<td></td>
<td>ch. 10</td>
<td></td>
</tr>
<tr>
<td>angles, arcs, chords, secants, etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Circles, using IBM Supposer (15)</td>
<td>Golembeki</td>
<td>McDougal, Littel</td>
<td>P:Sup-C, A:Sup-C</td>
</tr>
<tr>
<td>angles, arcs, chords, secants, etc.</td>
<td></td>
<td>ch. 10</td>
<td>M:Sketchpad</td>
</tr>
<tr>
<td>11. Circles Scenario (14)</td>
<td>Hallberg</td>
<td>AW</td>
<td>A:Geogeoexplorer, M-Sk</td>
</tr>
<tr>
<td>includes paper folding</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>problems involving circ., area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Circle Exploration (7)</td>
<td>Larson</td>
<td>McDougal, Littel</td>
<td>P:Sup-C</td>
</tr>
<tr>
<td>includes polygons, billards</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>angles, arcs, chords, secants, etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Circles, Chords, Secants ...</td>
<td>Meyer</td>
<td>Jurgensen, (HM)</td>
<td>M:Sketch</td>
</tr>
<tr>
<td>includes Sketchpad introduction</td>
<td></td>
<td>ch. 7</td>
<td></td>
</tr>
<tr>
<td>uses computer &amp; traditional tools</td>
<td></td>
<td>ch. 9</td>
<td></td>
</tr>
<tr>
<td>17. Construction Unit (15)</td>
<td>White</td>
<td></td>
<td>Sup-T</td>
</tr>
<tr>
<td><strong>Eighth Grade Geometry:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Geometry Potpourri (20)</td>
<td>Scharf</td>
<td></td>
<td>M:A:Presup</td>
</tr>
<tr>
<td><strong>Lines:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Perspective and Reflection:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Perspective &amp; Reflections (22)</td>
<td>Remington &amp; Lee</td>
<td></td>
<td>M:Sketch</td>
</tr>
<tr>
<td>patterns, art</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polygons:</td>
<td>Nagel, Wally</td>
<td>UCSMP, Serra &amp; McDougal, Littel</td>
<td>M:A:Sup-T,Q</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------</td>
<td>---------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>21. Conjecturing w/ Polygons (12) properties and relations</td>
<td>Althoff</td>
<td>Jurgensen (HM)</td>
<td>M:Sketch</td>
</tr>
<tr>
<td>22. Quadrilaterals (12) properties and relations</td>
<td>Kuehne</td>
<td>AW, ch.5</td>
<td>M:Sup-Q</td>
</tr>
<tr>
<td>23. Quadrilaterals (15) properties and relations</td>
<td>Shouts</td>
<td>McDougal, Littel</td>
<td>M:Sup-Q</td>
</tr>
<tr>
<td>24. Quadrilaterals (15) properties and relations</td>
<td>Clark</td>
<td>Yunker (Merrill)</td>
<td>M:Sup-T,Sketch</td>
</tr>
<tr>
<td>25. Similarity (12) similar figures &amp; dilations</td>
<td>&amp; Wong</td>
<td>Jurgensen (HM)</td>
<td>M:Sup-T</td>
</tr>
<tr>
<td>27. Similar Polygons (13) includes dilations</td>
<td>Forbes</td>
<td>Jurgensen</td>
<td>A:Sup-T</td>
</tr>
<tr>
<td>28. Similar Shapes (17) size transformations</td>
<td>Hahn</td>
<td>UCSMP</td>
<td>A:Sup-T</td>
</tr>
<tr>
<td>29. Similarity ('4 ) size trans., golden ratio</td>
<td>Kelley</td>
<td>McDougal, Littel</td>
<td>A:Sup-T, Trans</td>
</tr>
<tr>
<td>30. Trans. &amp; Congruence intro. to computers &amp; conjecturing</td>
<td>Bear</td>
<td>UCSMP</td>
<td>M:Sketch</td>
</tr>
<tr>
<td>32. Transformations (13) as products of reflections</td>
<td>Maus</td>
<td>UCSMP</td>
<td>A:Trans</td>
</tr>
<tr>
<td>33. Trans. w/ Computer (20) a series of computer lessons</td>
<td>Peterson &amp; Sorensen</td>
<td>Jurgensen (HM)</td>
<td>A:Trans</td>
</tr>
<tr>
<td>35. Transformation Scenario (17) properties, Escher drawings</td>
<td>Payne</td>
<td>Jurgensen (HM)</td>
<td>A:Trans</td>
</tr>
<tr>
<td>Triangles:</td>
<td>Rooseenrad</td>
<td>McDougall,Littel</td>
<td>A:Sup-T</td>
</tr>
<tr>
<td>37. Triangles &amp; Constructions (20) explores properties of triangles</td>
<td>Halvorson</td>
<td>Sunburst</td>
<td>Sup-T</td>
</tr>
<tr>
<td>38. Congruence of Triangles includes reflection &amp; symmetry</td>
<td>Pearson</td>
<td>Holt</td>
<td>M:Sup-T</td>
</tr>
<tr>
<td>39. Triangles Using the Geometric Supposer terms, properties, relations</td>
<td>Sormeberg &amp; LaVelle</td>
<td>UCSMP</td>
<td>M:Sup-T</td>
</tr>
<tr>
<td>40. Conjecturing with Triangles (15) measures of angles, areas, per.</td>
<td>Lightfoot</td>
<td>AW, ch.9</td>
<td>M:Sketch</td>
</tr>
<tr>
<td>41. Triangles</td>
<td>Falch</td>
<td>Jurgensen (HM)</td>
<td>P:Sup</td>
</tr>
<tr>
<td>42. Right Tri. &amp; Trigonometry (15)</td>
<td>Sorteberg &amp; LaVelle</td>
<td>UCSMP</td>
<td>M:Sup-T</td>
</tr>
</tbody>
</table>
APPENDIX H

GEOMETRY ACTIVITY GUIDELINES
Name: ____________________________ Date: ______

Technology:

- Geometry Software: [ ]
- Overhead projector [ ]
- Paper and pencil [ ]
- Geometry instruments [ ]
- Folding paper [ ]

- Geometric Supposer [ ]
- Geometers Sketchpad [ ]

Topic:

- Triangles
- Quadrilaterals
- Circles

Van Hiele Levels:

- Level 1
- Level 2
- Level 3

Setting:

- One computer:
- Computer Lab

How will students work?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperatively</td>
<td>Emphasis on discussion</td>
</tr>
<tr>
<td>Groups</td>
<td>Emphasis on dividing the task</td>
</tr>
<tr>
<td>Individually</td>
<td>Emphasis on analysis</td>
</tr>
<tr>
<td>Individually</td>
<td>Emphasis on drill and practice</td>
</tr>
<tr>
<td>Teams</td>
<td>Emphasis on cooperation</td>
</tr>
<tr>
<td>Whole class</td>
<td>Emphasis on lecturing</td>
</tr>
</tbody>
</table>

Rationale:

(1/2 page)
THE ACTIVITY
(1 or 2 pages)

You should consider the following points in the design of your activity:

- Concept(s), skill(s), or procedure(s) to be taught.
- Goal(s) or objective(s) of the activity.
- What the student should know before carrying out the activity.
- What will the student have to do to learn what you want him/her to learn?
- When will the student use the technology?
- How will the student use the technology?

EVALUATION/ASSESSMENT
(1 page)

You should consider the two following aspects to be evaluated:

- How will you know whether the student learnt what you wanted him/her to learn?
- How will you determine whether you accomplished your goal(s) or objectives(s)?
APPENDIX I

GEOMETRY SOFTWARE WORKSHOP EVALUATIONS
GEOMETRY SOFTWARE WORKSHOP

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES[ ] NO[ ]

If you want to receive information about any coming workshop to introduce mathematics software, please give your name, address, and phone number:

Name: ______________________________________
Address: ______________________________________
______________________________________________
______________________________________________
Phone number: ________________________

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce inservice high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McIntosh or to Ellie Galindo in room 220.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

   YES[ ] NO[ ]

   Why? __________________________________________

2. Did you find useful the demonstration of the Geometer's Sketchpad?

   YES[ ] NO[ ]

   Why? __________________________________________

3. Did you find useful the booklets designed for the workshop?

   YES[ ] NO[ ]

   Why? __________________________________________

4. Did you find useful the geometry activities presented in the workshop?

   YES[ ] NO[ ]

   Why? __________________________________________

5. How this workshop could be improved?

   ____________________________________________

   ____________________________________________

   ____________________________________________
GEOMETRY SOFTWARE WORKSHOP

CASE A: ISTJ

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES [✓]  NO [ ]

If you want to receive information about any coming workshop to introduce mathematics software, please give your name, address, and phone number:

Name: ________________________________
Address: ________________________________
Phone number: ________________________________

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce interactive high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McLaughlin in room 320.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES [✓]  NO [ ]

Why? ________________________________

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES [✓]  NO [ ]

Why? ________________________________

3. Did you find useful the booklet designed for the workshop?

YES [✓]  NO [ ]

Why? ________________________________

4. Did you find useful the geometry activities presented in the workshop?

YES [✓]  NO [ ]

Why? ________________________________

5. How this workshop could be improved? ________________________________

I am really glad this type of workshop is being done.
GEOMETRY SOFTWARE WORKSHOP

CASE 1B: ENFP

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES [X] NO [ ]

If you want to receive information about any coming workshops to introduce mathematics software, please give your name, address, and phone number:

Name: [
Address: 
Phone number: 

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce inservice high school mathematics teachers to the use of mathematics software. Please return this survey to Professor Mcintosh or to Eide Galindo in room 3220.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES [X] NO [ ]

Why? [NEED MORE EXPLANATION AND NOT ENOUGH TIME]

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES [X] NO [ ]

Why? [SPENT MORE TIME SO IT WAS EASIER TO LEARN MORE]

3. Did you find useful the booklets designed for the workshop?

YES [X] NO [ ]

Why? [ ]

4. Did you find useful the geometry activities presented in the workshop?

YES [X] NO [ ]

Why? [SOME WERE AND SOME WERE NOT. SEEMS ASSUMED TO MUCH PREVIOUS KNOWLEDGE OF WORKSHOP WENT THE SKETCHPAD]

5. How this workshop could be improved? ONE WHOLE SESSION SHOULD BE DEVOTED TO HOW TO USE THE BASIC FEATURES OF THE SOFTWARE.

[ ]
GEOMETRY SOFTWARE WORKSHOP

CASE 14: ENFJ

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES[ ] NO[ ]

If you want to receive information about any coming workshops to introduce mathematics software, please give your name, address, and phone number:

Name: _____________
Address: ____________
Phone number: ________

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce innovative high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McKeown or to Ellie Gallardo in room 3220.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES[ ] NO[ ]

Why? ____________________________

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES[ ] NO[ ]

Why? ____________________________

3. Did you find useful the booklets designed for the workshop?

YES[ ] NO[ ]

Why? ____________________________

4. Did you find useful the geometry activities presented in the workshop?

YES[ ] NO[ ]

Why? ____________________________

5. How this workshop could be improved? ________________________________
GEOMETRY SOFTWARE WORKSHOP

CASE 18: inch INFP

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES[ ] NO[x]

If you want to receive information about any coming workshop to introduce mathematics software, please give your name, address, and phone number:

Name: 
Address: 
Phone number: ( )

INFP

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce in-service high school mathematics teachers to the use of mathematics software. Please return this survey to Professor Mcleash or to Elie Galindo in room 3220.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES[ ] NO [x]

Why? I couldn't use it properly, so I really didn't understand what meant.

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES[x] NO [ ]

Why? I love this software!

3. Did you find useful the booklets designed for the workshop?

YES[x] NO [ ]

Why? They were very helpful.

4. Did you find useful the geometry activities presented in the workshop?

YES[x] NO [ ]

Why? They were good for introducing me to the functions of the Sketchpad and giving me ideas when teaching in the future.

5. How this workshop could be improved? Either have the Supposer so we could use it or use other software too. has
GEOMETRY SOFTWARE WORKSHOP

CASE 15: 1979

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES[ ] NO[ ]

If you want to receive information about any coming workshops to introduce mathematics software, please give your name, address, and phone number:

Name: ____________
Address: ____________
Phone number: ____________

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce in-service high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McNichol or to Ellie Ganza in room 1220.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES[ ] NO[ ]

Why? ____________

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES[ ] NO[ ]

Why? ____________

3. Did you find useful the booklets designed for the workshop?

YES[ ] NO[ ]

Why? ____________

4. Did you find useful the geometry activities presented in the workshop?

YES[ ] NO[ ]

Why? ____________

5. How this workshop could be improved? ____________
GEOMETRY SOFTWARE WORKSHOP

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES[ ] NO[ ]

If you want to receive information about any coming workshop to introduce mathematics software, please give your name, address, and phone number:

Name: ______________________________________

Address: ____________________________________

___________________________________________

Phone number: ______________________________

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce interservice high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McNamara or to Ellek Galindo in room 223.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES[ ] NO[ ]

Why? _____________________________________________________________________

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES[ ] NO[ ]

Why? _____________________________________________________________________

3. Did you find useful the booklets designed for the workshop?

YES[ ] NO[ ]

Why? _____________________________________________________________________

4. Did you find useful the geometry activities presented in the workshop?

YES[ ] NO[ ]

Why? _____________________________________________________________________

5. How this workshop could be improved? Having some hands-on experience with the Geometer Supposer would be nice._

__________________________________________________________________________
GEOMETRY SOFTWARE WORKSHOP

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES [ ] NO [X]

If you want to receive information about any coming workshop to introduce mathematics software, please give your name, address, and phone number:

Name: ____________________________
Address: ____________________________
_______________________________
Phone number: (   ) __________________

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce interservice high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McIntosh or to Ellis Gallindo in room 3220.

EVALUATION

1. Did you find useful the demonstration of the Geometer's Sketchpad?

YES [X] NO [ ]

Why? I still really don't understand what it is.

2. Did you find useful the demonstration of the Geometric Supposer?

YES [X] NO [ ]

Why? I learned more from this presentation.

3. Did you find useful the booklets designed for the workshop?

YES [X] NO[ ]

Why? They were useful when I read them. There was just too much material to sort through.

4. Did you find useful the geometry activities presented in the workshop?

YES [X] NO [ ]

Why? I can't remember them.

5. How this workshop could be improved? More time. More focused. Enough time to pick the software and practice it. I don't feel I learned anything from the workshops.
GEOMETRY SOFTWARE WORKSHOP

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES[ ] NO[X]

If you want to receive information about any coming workshop to introduce mathematics software, please give your name, address, and phone number:

Name: ____________________________
Address: __________________________
_______________________________
Phone number: ( ) __________________

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce inservice high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McIntosh or to Ellie Galindo in room 3220.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES[ ] NO[X]

Why? Without having "hands-on" experience with the software, it was too difficult to follow what was happening.

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES[ ] NO[ ]

Why? But some of the activities were hard to follow in terms of what the student was to be learning.

3. Did you find useful the booklets designed for the workshop?

YES[ ] NO[ ]

Why? Most contained useful ideas.

4. Did you find useful the geometry activities presented in the workshop?

YES[ ] NO[ ]

Why? For the most part, they were very applicable.

5. How this workshop could be improved? More "hands-on" activities; more structured activities;
GEOMETRY SOFTWARE WORKSHOP
CASE 1.  ISFJ

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES[ ] NO[ x ]

If you want to receive information about any coming workshop to introduce mathematics software, please give your name, address, and phone number:

Name: 
Address: 
Phone number: 

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce inservice high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McMahon or to Ellie Gallindo in room 3220.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES[ ] NO[ x ]

Why? A more detailed handout would have been very good.

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES[ ] NO[ x ]

Why? I lack experience with this software so was glad to see the presentation but didn't know.

3. Did you find useful the booklets designed for the workshop?

YES[ ] NO[ x ]

Why? I could use the information and would like to see a student set up something similar for my own class.

4. Did you find useful the geometry activities presented in the workshop?

YES[ ] NO[ x ]

Why? Worked well. The class was manageable.

5. How this workshop could be improved? Have the students more involved. The one session where a student was using the Supposer with the class offering suggestions was very good.
GEOMETRY SOFTWARE WORKSHOP

CASE 4: 1973

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES[ ] NO[ ]

If you want to receive information about any coming workshops to introduce mathematics software, please give your name, address, and phone number:

Name:
Address:
Phone number:

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce inservice high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McNamara or to Ellie Galindo in room 3220.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES[ ] NO[ ]

Why? I was more comfortable with Sketchpad.

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES[ ] NO[ ]

Why?

3. Did you find useful the booklets designed for the workshop?

YES[ ] NO[ ]

Why?

4. Did you find useful the geometry activities presented in the workshop?

YES[ ] NO[ ]

Why?

5. How this workshop could be improved?

More time to have workshops over a longer period of time so you can enter the material thoroughly.
GEOMETRY SOFTWARE WORKSHOP

CASE E: E S F J

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES [ ] NO [ ]

If you want to receive information about any coming workshop to introduce mathematics software, please give your name, address, and phone number:

Name:
Address:
Phone number:

Your evaluation of the Geometry Software Workshop will be very useful in designing a course to introduce in-service high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McKelvey or to Ellie Caliendo in room 2230.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

   YES [ ] NO [ ]

   Why?

2. Did you find useful the demonstration of the Geometer's Sketchpad?

   YES [ ] NO [ ]

   Why? I enjoyed it but helpful to see more of it.

3. Did you find useful the booklets designed for the workshop?

   YES [ ] NO [ ]

   Why? I tried to work them on my own.

4. Did you find useful the geometry activities presented in the workshop?

   YES [ ] NO [ ]

   Why? They really helped me understand the concepts.

5. How this workshop could be improved?

   The workshop was very helpful, but it
   had a lot of material.
GEOMETRY SOFTWARE WORKSHOP

CASE 6: ENFP

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES [X] NO [ ]

If you want to receive information about any upcoming workshops to introduce mathematics software, please give your name, address, and phone number:

Name:
Address:
Phone number:

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce inservice high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McIntosh or to Ellie Cadiniso in room 320.

EVALUATION

1. Did you find useful the demonstration of the Geometric Superposer?
   YES [X] NO [ ]
   Why? ___________________________

2. Did you find useful the demonstration of the Geometer's Sketchpad?
   YES [X] NO [ ]
   Why? ___________________________

3. Did you find useful the booklets designed for the workshop?
   YES [X] NO [ ]
   Why? ___________________________

4. Did you find useful the geometry activities presented in the workshop?
   YES [X] NO [ ]
   Why? ___________________________

5. How this workshop could be improved? ___________________________
GEOMETRY SOFTWARE WORKSHOP

CASE 7: INTP

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES [ ]
NO [ ]

If you want to receive information about any coming workshop to introduce mathematics software, please give your name, address, and phone number:

Name:

Address:

Phone number:

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce in-service high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McIntosh or to Ellie Calando in room 3220.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES [ ]
NO [ ]

Why? [ ]

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES [ ]
NO [ ]

Why? [ ]

3. Did you find useful the booklets designed for the workshop?

YES [ ]
NO [ ]

Why? [ ]

4. Did you find useful the geometry activities presented in the workshop?

YES [ ]
NO [ ]

Why? [ ]

5. How this workshop could be improved?

[ ] Perhaps the Supposer could be available for use to work with. Also, it would help if thorough documentation was available to us for each piece of software.
GEOMETRY SOFTWARE WORKSHOP

CASE 9: ESP

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES [ ] NO [ ]

If you want to receive information about any coming workshop to introduce mathematics software, please give your name, address, and phone number:

Name: __________________________
Address: _________________________
Phone number: ____________________

Your evaluation of the Geometry Soft...

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES [ ] NO [ ]

Why? ____________________________

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES [ ] NO [ ]

Why? ____________________________

3. Did you find useful the booklets designed for the workshop?

YES [ ] NO [ ]

Why? ____________________________

4. Did you find useful the geometry activities presented in the workshop?

YES [ ] NO [ ]

Why? ____________________________

5. How this workshop could be improved? ____________________________

______________________________

______________________________
GEOMETRY SOFTWARE WORKSHOP

CASE 6: ENP

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES[ ] NO[ ]

If you want to receive information about any coming workshop to introduce mathematics software, please give your name, address, and phone number:

Name:
Address:

Phone number:

Your evaluation of the Geometry Software Workshop will be very useful in the design of a course to introduce inservice high school mathematics teachers to the use of mathematics software. Please return this survey to Professor McDaniel or to Ellie Gallardo in room 3229.

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES[ ] NO[ ]

Why?

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES[ ] NO[ ]

Why?

3. Did you find useful the booklets designed for the workshop?

YES[ ] NO[ ]

Why?

4. Did you find useful the geometry activities presented in the workshop?

YES[ ] NO[ ]

Why?

5. How this workshop could be improved?

How to make a lesson using the software?
GEOMETRY SOFTWARE WORKSHOP

Would you like to participate in a course (for free) in which you would be introduced to the use of mathematics software next summer?

YES( )  NO( )

If you want to receive information about any coming workshop to introduce mathematics software, please give your name, address, and phone number:

Name: ____________________________________________________________________________
Address: __________________________________________________________________________
Phone number: ______________________________________________________________________

EVALUATION

1. Did you find useful the demonstration of the Geometric Supposer?

YES( )  NO( )

Why? ______________________________________________________________________________

2. Did you find useful the demonstration of the Geometer's Sketchpad?

YES( )  NO( )

Why? ______________________________________________________________________________

3. Did you find useful the booklets designed for the workshop?

YES( )  NO( )

Why? ______________________________________________________________________________

4. Did you find useful the geometry activities presented in the workshop?

YES( )  NO( )

Why? ______________________________________________________________________________

5. How this workshop could be improved? ____________________________________________________________________________
APPENDIX J
VAN HIELE LEVELS
THE VAN HIELE MODEL

(Abstracted from van Hiele, 1986 and Flay, Geeddes, & Tischler, 1988)

The learner assisted by appropriate instructional experiences, passes through the following five levels, (the learner cannot achieve one level of thinking without having passed through the previous levels):

**Level 0**: The student identifies, names, compares and operates on geometric figures (e.g., triangles, angles, intersecting or parallel lines according to their appearance).

**Level 1**: The student analyzes figures in terms of their components and relationships among components and discovers properties/rules of a class of shapes empirically (e.g., by folding, measuring, using a grid or diagram).

**Level 2**: The student logically interrelates previously discovered properties/rules by giving or following informal arguments.

**Level 3**: The student proves theorems deductively and establishes interrelationships among networks of theorems.

**Level 4**: The student establishes theorems in different postulational systems and analyzes/comparisons these systems.

Learning is a discontinuous process and there are jumps in the learning graph that reveal the presence of levels.

![Figure 1. Levels of Thought](image-url)
At some points in the learning process, it seems that students stop learning though later on they will continue as they were. During the plateau, the teacher does not succeed in explaining the subject. Students who have not yet reached the new level cannot understand what the teacher says, like if the teacher were speaking a different language. Because of the teacher’s authority image, students tend to accept what is taught, but the subject will not sink into their minds. The pupil will not have a view of his/her on activity until he/she has reached the new level. Language structure is a critical factor in the movement through the van Hiele levels. Teachers tend to use the language of a higher level than is understood by the student.

The levels are characterized by differences in objects of thought. While at Level 0 the objects of thought are geometric figures (students identify shapes), at Level 1 students operate on those geometric figures. For instance, students discover properties that are characteristic of geometry figures and classify shapes according to these properties. At Level 2, these properties become the objects of thought that students act upon. Students create then a change of logical relationships (e.g., if a quadrilateral has opposite sides that are parallel, then the opposite sides are congruent). At Level 3, the process of logical deduction becomes the object of thought (that is, geometry proofs). Finally at Level 4, the foundations of logic systems are analyzed.

Teachers may facilitate students to learn geometry helping them to progress from one level to the next. Dina and Pierre Van Hiele suggest that instruction should include the following five phases:
• **Information**: The student gets acquainted with the working domain (e.g., examines examples and non-examples).

• **Guided orientation**: The student does tasks involving different relations of the conceptual map that is to be formed.

• **Explicitation**: The student becomes conscious of the relations, tries to express them in words, and learns technical language that accompanies the subject matter.

• **Free orientation**: The student learns, by doing more complex tasks, to find his/her own way in the conceptual map.

• **Integration**: The student summarizes all that he/she has learned about the subject, then reflects on his/her actions and obtains an overview of the newly formed network of relations now available.

The major characteristics of the van Hiele model are:

• The levels are sequential.
• Each level has its own language, set of symbols, and network of conceptual relationships.
• What it might not be clear at one level becomes obvious at the next level.
• Students will tend to memorize what is taught above their level of understanding.
• Progress from one level to the next depends on instruction experience.
• Students go through various phases in proceeding from one level to the next.

**Questions for students enrolled in the GSW:**

1. How cognitive structures are related to perceptual and emotional structures?
2. Do attitudes towards mathematics are considered in this model?
Lab 1

How to get into the activity?

TO DRAW A TRIANGLE USE THE FOLLOWING PROCEDURE:

1. Open a new sketch.
   - If necessary, turn on your Macintosh.
   - Double-click the Sketchpad icon.
   - The application starts and a new, empty sketch appears.
   - Click anywhere in the Sketchpad window to remove the title page from the screen.

2. Draw three points.
   - Click the Point tool.
   - Move the pointer to the sketch plane. The pointer changes to a crosshair shape.
   - Click anywhere in the sketch plane. The pointer appears where you clicked. The point is selected—it becomes highlighted. The Point tool is in effect.
   - Move the pointer in any direction in the sketch plane and click about two inches from the first point. A second point appears. The second point is selected, and the first one is not selected.
   - Move the pointer again and click to get another point.

3. Select the three given points.
   - Click one of the points.
   - Hold down the Shift key and click another point.
   - Continue holding down the Shift key and click the third point.

4. Click on Construct menu and drag the mouse down to select Segment command.

5. Did you draw a triangle?—If not, clear the current sketch.
   - Press and hold the Option key.
   - Choose Undo All from the Edit menu. Every object on the sketch disappears.

6. Try again.
Lab 1

Task

- Define a triangle.

Procedure:
- Use the Selection tool to select one of the vertex points and drag it around. The point you have selected moves, changing the triangle as you drag. Drag the vertex to make different types of triangles.

When am I finished?
- I have moved one vertex around the two others.
- I have gotten a straight line with the three points on it.
Lab 1

Name: ________________________________

Worksheet

Draw three triangles with different shapes, as you see them in the Sketchpad plane.

Draw a triangle with area zero.

To be a triangle a geometric shape needs to have:

   _____ vertices

   _____ sides

Define a triangle: ____________________  ____________________  ____________________
Lab 1

**Task:**
Investigate the measurements that produce triangles, given specific conditions.

**Procedure:**
1. Forming a triangle:
   - Examine each triangle to determine if it is a triangle or not.

2. Writing conjectures:
   - Form conjectures about the conditions under which certain segments form a triangle.

**When am I finished?**
- I have examined measurements in at least six side-side-side combinations.
- I found at least two sets of measurements that form triangles.
- I formed at least two different sets of measurements that do not form triangles.
- I have drawn labeled triangles that do not make a triangle.
- I have written a conjecture concerning the conditions under which these segments form a triangle.
- I have written a conjecture concerning the construction which does not form a triangle.

**How to get into the activity?**
1. Draw a triangle with given measurements.
2. Check if the given measurements form a triangle.
3. Form conjectures about the conditions under which these segments form a triangle.

Assign using my name first 1-3 in the order of the teacher's instructions.
Lab 2

Task

• Investigate the measurements that produce triangles given side-side-side.

Procedure:

• Record the three measurements of the segments in the workbook, whether or not a triangle is formed, and if so, what type of triangle it is.
• Draw twelve different lines which do not make a triangle.
• Write conclusions that answer the following questions:
  1. When will three segments form a triangle?
  2. When will three segments not form a triangle?

When am I finished:

I have written the measurements of at least eight side-side-side combinations.
I found at least two sets of measurements that form triangles.
I found at least two sets of measurements that do not form triangles.
I have drawn and labeled at least two figures that do not make triangles.
I have written a conjecture concerning the conditions under which three segments form a triangle.
I have written a conjecture concerning the conditions under which three segments do not form a triangle.

How to get into the activity?

TO INVESTIGATE THE MEASUREMENTS THAT PRODUCE TRIANGLES USE THE FOLLOWING PROCEDURE:

1. Choose New Sketch from the File menu.
2. Draw two points.
3. Connect the points with a segment.
4. Draw two more segments.
5. Display the labels for the segments and points.
6. Display and observe measurements for the segments.
7. Use the Selection tool to select the segments.
8. Drag the segments. Try to make a triangle.
9. If you do not get a triangle with the usual measurements of the segments, you may vary the length of the segments by dragging their endpoints by one of its end points. The measure of the length of the segments will change as you move the end points of the segment.
APPENDIX L

TRIANGULATION PROCEDURES
Patton (1980) describes three kinds of triangulation that contribute to verification and validation of qualitative analyses: triangulation of methods, triangulation of data sources, and investigative triangulation. He explains that "triangulation of methods will most often revolve around comparing data collected through some kind of qualitative methods with data collected through some kind of quantitative methods" (p. 329). The triangulation of data sources "means comparing and cross-checking consistency of information derived at different times and by different means within qualitative methods" (p. 331). Finally, "investigative triangulation which simply means that multiple as opposed to singular observers are employed" (p. 331). He points out that a related strategy is triangulating analysts, that is, "having two or more persons independently analyze the same qualitative data set and then compare their findings" (p. 331).

Validation of the Study

The verification and validation of the data analysis carried out in the present study was based on two types of triangulation: (1) triangulation of methods, that is, reconciling qualitative and quantitative data, and (2) triangulation of analysts, that is, two researchers analyzed the same set of data. This researcher's characterization of the four teachers reported in this Chapter 4 was first compared with the characterization given by Silver, and Hanson (1985) which is based on MBTI studies carried out in the
quantitative tradition. There were two reasons to involve a second researcher to verify this investigator's teachers characterization: (a) some aspects of the study that could not be compared with previous characterizations of schoolteachers, and (2) the characterization of the four selected teachers under those categories that could be compared with Silver, and Hanson's resulted very similar to that given by this authors. One possible explanation for getting a similar characterization to the Silver, and Hanson's could be that these authors and this investigator shared same MBTI readings on schoolteachers. Therefore, the second researcher should have no previous knowledge about MBTI schoolteachers characterization but this person should have experience analyzing qualitative data. Dr. Diana Lambdin who volunteered her time to carried out the data analysis is a qualitative researcher who declared having no readings on MBTI studies. This appendix describes the procedures followed to: (a) involve the second analyst, (b) the external researcher's categorization, (c) The triangulation of three characterization of teachers—Silver, and Hanson's, the external researcher's, this investigator's.

Procedures Followed by the External Researcher

Prior to the design of the triangulation of the interview data, this investigator met for half an hour with the external researcher
to discuss the activity. Two days later, five tables and 28 cards were given to her. Although one week was allowed for the triangulation process, it took few hours the categorization of paragraphs, though the exact time devoted to the activity is unknown. The procedures for the triangulation of the interview data involved three stages: (1) The design of an unbiased procedure; (2) The design of the tables to be used by the external researcher; and (3) The categorization. Each of these points were discussed with her and are described in what follows.

1. Each of the 28 paragraphs of the interview transcripts containing the interview segments reported in Chapter 4 (Tables 19, 20, 21, 24, 25, 26, and 27) were copied and pasted on 5"x8" cards. To avoid or minimize the possibility of identifying a sequence of paragraphs with a person, first the MBTI labels were covered, and then all the cards were scrambled. Each card was numbered. In this way the researcher was sorting paragraphs without having any reference of the persons who had been interviewed. The researcher sorted the four selected teachers' responses to the items 6, 7, 8, 9, 12a, 12b, and 12c of the modified protocol of the interview (see Figure 11).

Each card had written on it the following items: (a) a title, (b) the paragraph number, (c) the item of the interview, (d) and the interview paragraph (see Figure 13). The title corresponded to the name of the category under the interview item, and it was
originally placed by this investigator. However, the researcher was
told that she could assign the response paragraph to as many of
five categories as she considered appropriate. For instance, Figure
13 shows that the response given to item 9—"How are you going to
evaluate understanding?"—indicates that this teacher prefers to
evaluate students individually rather than team work. This answer
says something not only about this teacher's preferred evaluation
methods but also about class interactions.

![Interview Item Diagram]

**Figure 15. Sample of the Cards Used in the Triangulation of the Interview Data**

2. Five tables were given to the researcher. One table per
category: (a) teaching strategies, (b) evaluation methods, (c)
classroom interactions, (d) teaching styles, and (e) computer uses.
Each table contained a list of subcategories on the left side and
the researcher could write the paragraph number at the right of the subcategory that better described or characterized the action contained in a specific interview paragraph (see Figure 16).

3. Figure 16 includes a copy of the tables that were given to the external researcher and her assignation of four selected teachers' responses under the given categories—teaching strategies, teaching styles, evaluation methods, classroom interactions, and computer uses. This information was used to construct the triangulation tables reported in Chapter 4.

The External Researcher’s Categorization

This investigator could recognize each of the four teachers with a sequence of numbers, but the external researcher did not have a clue to know what sequence of paragraphs corresponded to each of them. Table 40 contains the key used to identify each of the four preservice secondary teachers.
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**Figure 16.** Tables Used by the External Researcher
**Table 40** Key to Identify the Four Selected Teachers

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Using the descriptors for the categories included in Figure 16, the external researcher's characterization of the four selected teachers was gotten (see Table 41).
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<td>Individual exploration</td>
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Table 41. The External Researcher's Categorization
APPENDIX M

HUMAN SUBJECTS

245
October 13, 1993

Harenida Garcia Tello
2379 South Worthington Lane
Bloomington, Indiana 47401

Re: Protocol No. 93B0137

Dear Mrs. Tello:

Per our telephone discussion this date regarding your move to Indiana and the effect on the above referenced protocol which was approved as exempt on May 4, 1993, you do not need to submit anything further to the Committee. Since your procedures did not change, only the subject population and location, the protocol you submitted will continue to cover your research.

If I can be of further help, please do not hesitate to contact me.

Sincerely,

Angela D. Kalb, Secretary
Behavioral and Social Sciences, Human Subjects Review Committee

ADK
NOTICE OF APPROVAL
EXEMPT REVIEW

TO: Herandira Galindo
Education

DATE: October 1, 1993

FROM: Cybil Cole, Research Risk Compliance Officer
Bloomington Campus Committee for the Protection of Human Subjects

RE: Protocol entitled: Exploration of the Relationship Between Personality Type of Preservice Secondary Mathematics Teachers, as Determined by the MBTI, and Selection and Use of Geometry Software

Approval Date: October 1, 1993

The Human Subjects Committee (HSC) has reviewed and approved the research protocol referenced above as exempt: § 101b, 1#1 & 2. Please note the following requirements:

AMENDMENTS: If you wish to change any aspect of the study (such as design, procedures, study information sheet/consent form, or subject population), please contact the Risk Compliance Officer for the appropriate form to use. The new procedure may not be initiated until HSC approval has been given.

COMPLETION: You are required to notify the HSC office when your study is completed. You may do this by memo.

We suggest you keep this memo with your copy of the approved protocol.

Sponsored Research Services
Bryan Hall 001
Bloomington, Indiana
47405-1219
812-855-0516
Fax: 812-855-9945
LIST OF REFERENCES


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