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ABSTRACT

Getting to the Fourth Year is a study being conducted by the Teacher Research Network (TRN) in Minnesota. The TRN was established in 1998 by five higher education institutions that collectively prepare about 75% of all K-12 teachers in the state. The vision of the collaborative was to begin the process of transforming teacher education in mathematics and science so that teachers will be prepared to teach according to the vision of present and future national standards and continue learning new content and new ways of teaching throughout their professional careers. This TRN Study project was established to collect information about the practice of beginning K-12 science and math teachers in Minnesota in their first 3 years of teaching. Minnesota has seen a high percentage of beginning science and math teachers drop out of teaching during their first three years of teaching. The study looks to determine what factors might be causing this high drop out rate. Specifically, the research questions of the study are: (1) what are new teachers current practice, knowledge, and beliefs about teaching science/math? and (2) what is the context in which new teachers teach science/math? (Author/MVL)

GETTING TO THE FOURTH YEAR: THE INSTRUMENTS AND PROTOCOLS USED TO STUDY THE PRACTICE OF BEGINNING K-12 SCIENCE TEACHERS

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Beginning Science Teacher Study

Getting to the Fourth Year is a study being conducted by the Teacher Research Network (TRN) in Minnesota. The TRN was established in 1998 by five higher education institutions that collectively prepare about seventy five percent of all K-12 teachers in the state. The TRN is a project of the Transforming Teacher Education Initiative (TTE). The Transforming Teacher Education Initiative, a group of Minnesota faculty from higher education and K-12 schools, was developed to work with state policy makers in aligning state and national standards for K-12 students and teachers. The vision of the collaborative was to begin the process of transforming teacher education in mathematics and science so that teachers will be prepared to 1) teach according to the vision of present and future national standards and 2) continue learning new content and new ways of teaching throughout their professional career. The TTE is a division of SciMath^{MN} that provides the funding for this TRN study. Dr. George Davis from Minnesota State University Moorhead and Dr. Patricia Simpson from St. Cloud State University serve as co-directors of the Teacher Research Network.

SciMath^{MN} is a statewide, public/private partnership that was incorporated in 1993 to work in Minnesota to increase the educational achievement and participation of all Minnesota students in science and mathematics. It has done so by promoting standards-based policy; professional development and practice; and, public awareness and engagement. SciMath^{MN} staff serve as project managers within each of these areas. Bill Linder-Scholar is the Executive Director of SciMath^{MN}.

The primary purpose of TRN was to devise a plan of study and instruments to assess the current status of our beginning mathematics and science teachers that we define as those in their first three years as teachers. Additionally, TRN encouraged the collaboration of science and mathematics education researchers and provided those researchers with financial support and on-going professional development opportunities.

Purpose of Study

The TRN Study project was established to collect information about the practice of beginning K-12 science and math teachers in Minnesota in their first three years of teaching. Minnesota has seen a high percentage of beginning science and math teachers drop out of teaching during their first three years of teaching. The study looks to determine what factors might be causing this high drop out rate. Specifically the research questions of the study are:

- What are new teachers' current practice, knowledge and beliefs about teaching science/math?
- What is the context in which new teachers teach science/math?

Origins of the Study

As a result of SciMath^{MN}'s participation in the Salish II project, five teacher preparation institutions came together to explore the possibility of a joint study into the practice of Minnesota's beginning teachers of science and mathematics. From this initial meeting TRN was established and funded by SciMath^{MN}. The Teacher Research Network met several times during its first year to investigate the research process used by Salish I and II and their findings, as well as other scholarly work related to teacher assessments. These included the Interstate New Teacher Assessment and Support (INTASC) portfolio project and the Praxis exams used by our state. From these existing investigations and instruments came the current protocols and study instruments used by TRN.

Operation of the Study Network

Currently, the TRN group meets two to three times a year. The meetings provide an opportunity for researchers to discuss the use of the instruments, their findings and raise questions and concerns about the study protocols. Discussions have centered on each instrument, how it has worked, the results, what the results tell us about our research questions and whether or not modifications are needed in instruments or procedures. When instruments are changed, training on the instruments and their analyses are provided at the meetings. Lately, discussions about the analysis and reporting of study findings are common. Meetings are also a time for professional development related to issues associated with research on teaching and learning. Each university is required to send representatives to these meetings and ensure that all university team members understand what is to be done.

Each participating university has a team composed of full-time faculty at the teacher preparation institution. Each team has a contact person who is responsible for the efforts of their institution and for maintaining communication with the directors of the project. All TRN members serve as researchers investigating beginning science and mathematics K-12 teachers. Members may also choose to serve the TRN collaborative as members of special interest groups. These groups work on development of individual instruments, compilation of data, or interpretation of data. Institutional teams apply annually to SciMath[MN] for grants to financially support the work being done by their team members. Grants primarily support participating teacher stipends, travel, materials costs and transcription fees. SciMath[MN] also provides support to the network as a whole for TRN meetings, speakers, staff and other resources necessary to keep the network running.

University teams agree to the use of a common set of instruments and procedures chosen for use each year. Every team collects data from individual teachers, no more than two teachers per researcher, as outlined by the network's study procedure and returns the data to the special interest groups responsible for its analysis. Once the common research goals of the organization are met, individuals or teams may additionally choose to investigate additional research questions by using the same instruments with other student populations. Currently the TRN network includes ten institutions. The initial five universities (Minnesota State University Moorhead, St. Cloud State University, University of Minnesota Duluth, Gustavus Adolphus College and St. Mary's University) have been joined by five other teacher education institutions (The College of St. Scholastica, St. Thomas University, Winona State University, Minnesota State University-Mankato, and the College of St. Benedict/St. John's University). During the 2000/2001 academic year, faculty at each institution administered four instruments to mathematics and science teachers in their first, second or third year of practice. Approximately 50 K-12 teachers participated in the project.

Study Instruments

The CLES 2(20), Modified Constructivist Learning Environment Survey, was modified from the Constructivist Learning Environment Survey (CLES). The CLES was developed "... to enable teacher-researchers to monitor their development of constructivist approaches to teaching school science..." (Taylor, Dawson, & Fraser, 1995, p.1). Originally developed by Peter Taylor and Barry Fraser at Curtin University of Technology in Perth, Australia (Taylor, Fraser, & Fisher, 1993) the CLES consisted of 28 items, seven each in four scales - autonomy, prior knowledge, negotiation, and student-centeredness. The instrument was later revised to incorporate a critical theory perspective because "... our ongoing research program had revealed major socio-cultural constraints (e.g., teachers acting in accordance with repressive cultural myths of cold reason and hard control) that worked in concert to counter the development of constructivist learning environments." (Taylor, et al., 1995, p. 2).

The revised CLES was used in the first year of this study consists of 30 items, six each in five scales (see Table 1). Rather than having items from different scales mixed together throughout the instrument, items in this version are grouped by scale. In addition, there is only one item that is negatively worded. The items attempt to reveal teachers' perceptions of the learning environment in their classrooms. Versions for both science teachers and for their students were produced.

Table 1

Constructivist Learning Environment Survey CLES Scale Descriptions

Personal Relevance -

"Extent to which school science/mathematics is relevant to students' everyday out-of-school experiences."

Uncertainty -

"Extent to which opportunities are provided for students to experience that scientific/mathematical knowledge is evolving and culturally and socially determined."

Critical Voice -

"Extent to which students feel that it is legitimate and beneficial to question the teachers' pedagogical plans and methods."

Shared Control -

"Extent to which students have opportunities to explain and justify their ideas, and to test the viability of their own and other students' ideas."

Student Negotiation -

"Extent to which students share with the teacher control for the design and management of learning activities, assessment criteria, and social norms of the classroom."

Note: All scale descriptions are taken from: Taylor, Fraser, & Fisher, 1997.

Exploratory factor analysis and internal consistency (alpha) reliability, as well as examination of each item and of participants' questions and comments about them, led to the development of a revised survey (Johnson, 1990), renamed the Constructivist Learning

Environment Survey 2(20) [CLES2(20)]. The revised survey retains the same five scales included in the CLES but reduces the number of items from 30 to 20, four in each scale. In addition, several items were reworded or replaced with new items. The sole negatively worded item was replaced with a positively worded item. Items were grouped by scale as in the CLES.

In this study, we use the CLES2(20) with both science teachers and with their students. Each teacher who participates in the study completes the appropriate teacher form, giving us a picture of how he or she views the classroom environment in his or her own classroom. At the same time, the teachers' students complete the student form, giving us the students' perceptions of the classroom environment.

The results that we get from the CLES2 (20) are a source of information for use, along with classroom observations and teacher interviews, in writing teacher profiles (Davis & Simpson, 2000). The five CLES2 (20) scales align with teacher profile categories as shown in

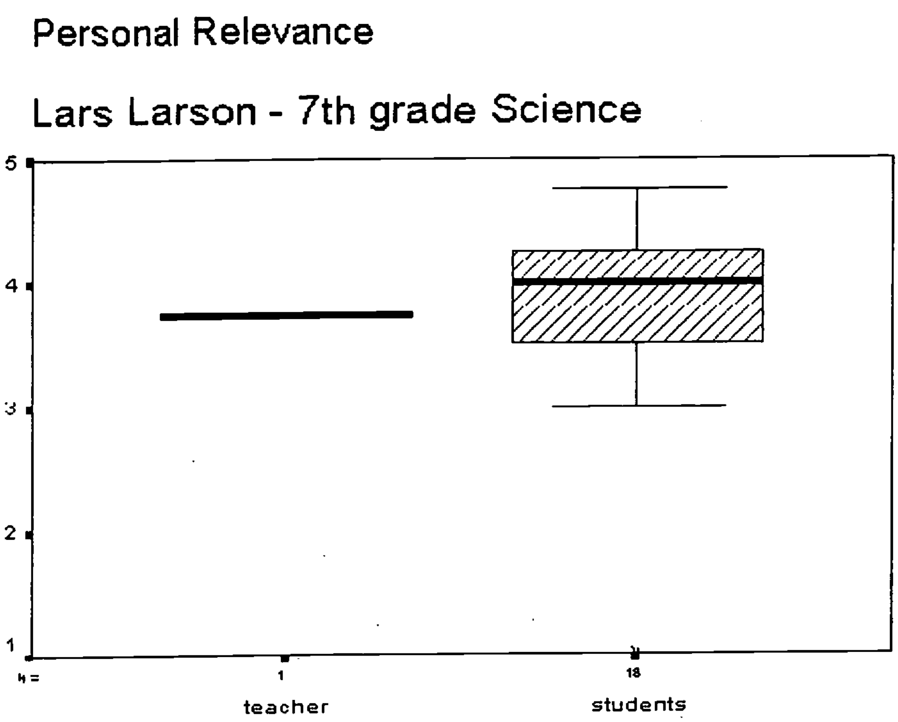
Table 2.

Alignment of CLES2 (20) Scales with TRN Profile Categories

CLES Scale	TRN Profile Category
Personal Relevance	Knowledge of Content
Uncertainty	Knowledge of Content
Critical Voice	Knowledge of Students
Shared Control	Knowledge of Pedagogy
Student Negotiation	Knowledge of Pedagogy & Knowledge of Students

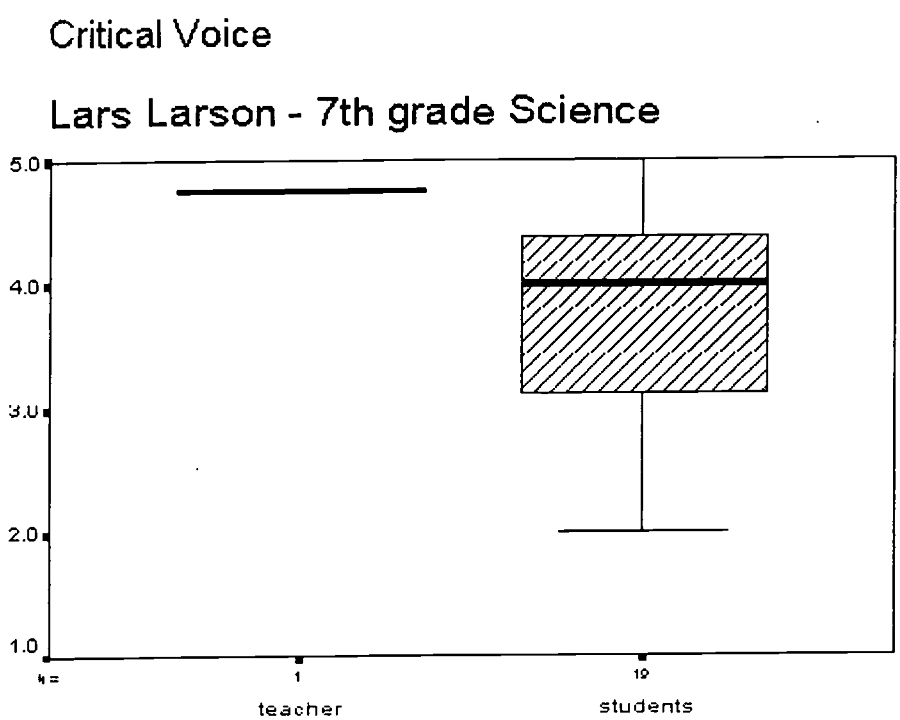
To interpret the CLES2 (20) data, those writing the profiles receive graphs showing how the teacher's perceptions compare with those of his or her students for each scale. For example, Lars Larson, a 7th grade science teacher, has perceptions of his classroom environment that for some scales fit with those of his students and for other scales are rather different. Figure 1 shows the personal relevance scale. Lars sees the relevance of the content in his classroom as being fairly high, M = 3.75 on a scale of 1 to 5. His students for the most part agree with him. The students' mean (M = 3.81) is essentially the same as their teacher's, and the variation is not great.

Figure 1.



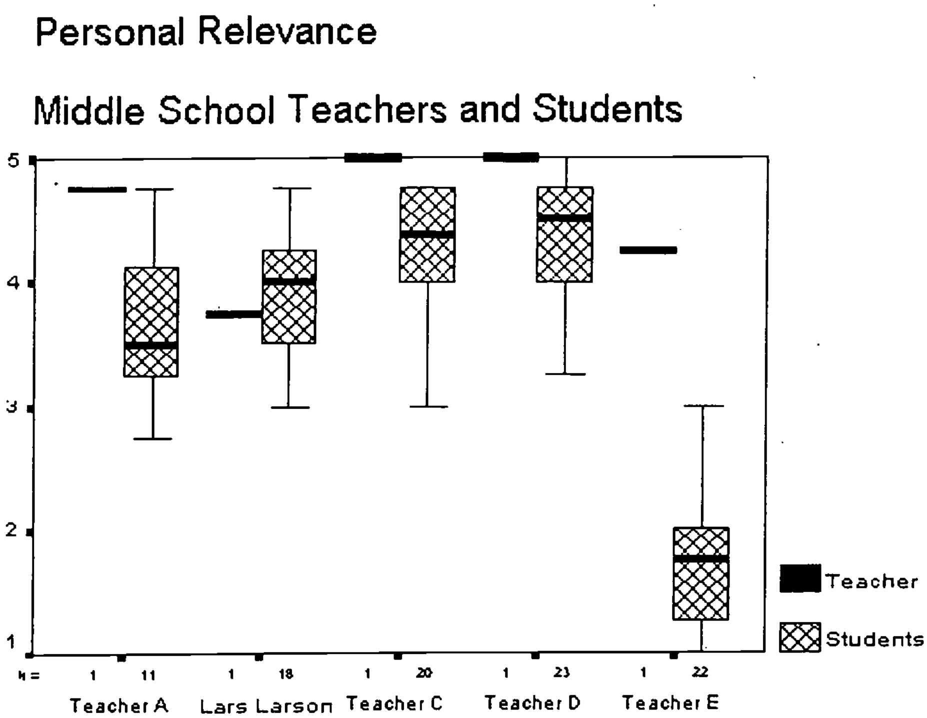
For the critical voice scale, however, the views of the Lars and of his students differ substantially. The teacher views his classroom as having a high degree of "critical voice" (M = 4.75 on a scale of 1 to 5). His students (figure 2) have a lower mean (M = 3.80) and a wide range of views. Clearly, most students do not feel as free about questioning the teacher's plans and pedagogy as the teacher thinks they do.

Figure 2.



Another way to look at this data is to compare classrooms. Figure 3 shows how this class compares with other middle school science classes for the personal relevance scale. Three of the other teachers rated it higher in their classrooms than Lars did in his, and in those cases the students were not too far below the teachers. In one case (Teacher E), though, the students emphatically disagreed with the teacher, rating personal relevance as very low.

Figure 3.



In this study, the CLES2 (20) provides important teacher and student perspectives that contribute to profiles of the teachers and their classrooms, giving us a better understanding of how our graduates are teaching.

<u>Minnesota Science Teacher Observation Instrument</u>

The Minnesota Science Teacher Observation Instrument (MNSTOI) is a structured observation instrument used to collect data within the classroom. The instrument organizes the observation process around the five characteristics of quality teacher preparation identified by Minnesota (Simpson and Wallace, undated). All data collection is organized in the TRN process around these same five characteristics. Focus questions direct observations within each category and these are further defined by specific prompts designed to guide the researcher. These prompts are meant to ensure that every researcher examines a teacher in as similar a manner as possible.

<u>Origin of the instrument</u>

The MNSTOI was its origins in three sources. The format of the instrument was taken from the Educational Testing Service's Praxis format. We use a pre-observation questionnaire, an observation and a post-observation questionnaire. We had originally investigated using the Praxis observations for the project but decided to develop our instrument due to the cost of the instrument, the intensive training required for use and the fact that it was not science specific.

The conceptual framework of the instrument was developed from Transforming Teacher Education: A Minnesota Framework for Science and Mathematics (TTE) (Simpson and Wallace, undated). This document was developed ten years ago and was developed to reflect current research, best practice and the beliefs of major Minnesota stakeholders about the knowledge and skills needed by beginning teachers of mathematics and science. The document provides standards for what beginning teachers should know and be able to do. These standards are divided into five sections, content, pedagogy, students as learners, establishing an environment for learning and developing as a teacher of science.

The third source used in the development of the document was the assessment guide developed for the (INTASC) portfolio project (Collins, 2002). This project developed a series of instruments that were designed to analyze a teacher portfolio. Included in that portfolio were teacher reflections, lesson plans, student work and videotapes of two lessons. The portfolio instruments include a series of prompts that examined teacher practice in light of the INTASC standards. Our MNSTOTI modified those prompts to better align with the TTE framework.

MNSTOI Components for Each Observation

Each teacher observation begins with examination of the teacher's demographic information. This included information about the teacher's background, school, the class being observed, course and student data. The teacher has previously competed a pre-observation questionnaire with 13 questions which includes a lesson description, including goals and a rationale that supports the teachers choices about her choice of activities, materials and assessments, Three students are selected by the teacher to represent diversity in the classroom and the teacher describes how the lesson has been modified to meet the needs of these students. Items for teacher comment are included for all five-teacher knowledge categories used in this study.

After examining the pre-questionnaire, the researcher makes a brief sketch of the classroom and begins the structured observation. At the conclusion of the observation, the teacher instructs the teacher to complete the post-observation questionnaire with 11 items and return it to the researcher within a period of one week. The post observation questionnaire allows the teacher to reflect on both her performance and that of the students. The teacher is asked to suggest if changes are needed for future lessons or for use of this lesson in another class. The teacher is also asked to comment on a need for support in terms of resources or advice to help improve the lesson

At the completion of each observation, the researcher is asked to write a summary of the lesson. This summary includes information from the lenses of the teacher through information provided in the two questionnaires and the lens of the researcher through what was observed. The report is organized around the teacher knowledge categories used in this study.

Two observations of the classroom are conducted. Both observations are selected at the convenience of the teacher and the researcher. The teacher identifies one lesson as having an inquiry focus and the second lesson is selected to represent a lesson in which a concept is being developed.

Table 3

Outline of Observational Process

Initial Visit

Share purpose of research and overall procedures; Introduce forms; and, describe the reward process.

First observation

Review teacher comments on demographics and pre-observation forms; Sketch classroom; complete notes of observation; and, Make arrangements to obtain post-observation form.

Lesson Report

Use all available data to complete a summary of the lesson organized teacher knowledge categories.

Second Observation

Repeat same process as for first observation and complete a report on the second lesson.

To provide detail for the entire observation instrument is too complex a process for this paper. Instead, what follows is information only from the section on pedagogy. This should give the reader some sense of the level of detail involved in the entire instrument.

Within the category of pedagogy, there are seven focus questions with a total of 23 prompts. Table 4 list the seven focus questions used for the observation. Four prompts are used to guide the researcher in using classroom observation to answer the question: In what kinds of science activities does the teacher engage the student? All four of the prompts associated with this question are listed in Table 5.

Table 4

Pedagogy Focus Questions

1. In what kinds of science activities does the teacher engage the student?
2. In what ways are, the activities appropriate for the instructional goals and objectives?
3. What different kinds of thinking predominate in the oral and written discourse of the classroom?
4. What is the teacher's role in fostering the oral and written discourse in the classroom?
5. In what ways does the teacher assess students' learning?
6. In what ways does the teacher communicate about the formal and informal assessments?
7. Have the students achieved the goals of learning science provided by this instructional sequence?

Table 5

Prompts associated with kinds of science activities

- Describe the variety of activities in which students engage.
- Describe the kinds of science understanding and ability the activities promote (e.g., conceptual understanding, factual recall, problem solving, application, communication)
- Describe how activities are planned (placed in instructional sequence, time allotted for tasks, use of materials, organization)
- Describe the implementation of the activities (e.g., implementation as planned, rich activities become procedural in nature, activities have potential but are used inappropriately by the teacher, activities get expanded based on student interest)

This final segment provides an example of a section of the report generated by the researcher for the question about the kinds of science activities used by the teacher to engage students. It incorporates information from the both teacher questionnaires and the observation of a lesson on genetics. Notice that the emphasis of the report is on evidence collected from the observations and questionnaire and that the researcher does not attempt to interpret the data collected at this point in time. The teacher has identified this lesson as one that develops important concepts related to genetics. This lesson had to be modified by the teacher to accommodate instruction loss of the previous days class due to snow. The researcher also had copies of the notes given that day and the genetics packet referenced by the teacher.

"The lesson observed included an introduction to a genetics unit. The purpose of the genetics lesson was to introduce the basic terms of genetics (pre-interview). The genetics class began with general announcements, an overview of instruction for the week, and a return of cell quizzes. In the weekly overview, the teacher stated computer simulations were to be used later in the week (MNSTOI). Students were provided with a packet on genetics that included genetics problems and associated questions. Notes were given on genetics information. According to the teacher, only essentials were provided on the overhead notes (3 pages), the teacher also explained and asked questions throughout the note taking process. Students and teacher worked together on Punnett Square problems from page 1 of the packet; page 2 was assigned for homework. The majority of the class focused on developing conceptual understanding of genetics with an introduction to the use of a tool (Punnett Square). The organization of the activities was appropriate. It began with an overview of the unit, an introduction to concepts and a chance to use the information from the notes in another way. (MNSTOI). The note taking section of the class was shortened to compensate for a snow day. The teacher believed the activities met the teacher's objectives for the day (post interview).

Minnesota Science Teacher Interview Instrument

The Minnesota Science Teacher Interview Instrument (MNSTII) is a structured interview instrument used to collect information from a practicing K-12 science teacher. Its fifteen questions (with their prompts) are also organized around the five characteristics of quality teacher preparation identified by Minnesota (Simpson and Wallace, undated).

Origin of the instrument

The MNSTII has it origin with the TPPI interview instrument developed by the SALISH project. The MNSTII differs from the TPPI as it asks fewer questions and its questions are aligned and limited to the five characteristics of quality teacher preparation identified by Minnesota.

Interview Procedure

The use of MNSTII is the last step in the study of a participating classroom teacher. It is important that the interview be last so that points discussed in the interview do not tip off the participating teacher to any observer or study emphasis. The average interview takes sixty to ninety minutes and is audiotaped. When interviewing elementary teachers about their science teaching, they are reminded that the interview questions asked are directed only at their science instruction. The tape is then transcribed verbatim. The tape and verbatim transcription are both used in the analysis.

Following the practice of this presentation I will focus now on the interview questions for the section on pedagogy. In the pedagogy section of the MNSTII are three questions with their respective prompts.

Table 6

Knowing Pedagogy Questions and Prompts:

What kinds of science activities do you use? Probe for:

> -This person's definition of "activity" (What counts as an activity?)
> -Ratio of engaged activities to seat work/lecture during science class
> *(Comment: For our purposes, "engaged activities" means investigation, demonstrations, projects, questions, problems, applications, and exercises in which students actively engage. "Seat work/lecture" reflects a passive role for students who are working on lower order questions, definitions, crossword puzzles, or listening to a lecture. Interviewers are asked to avoid stating these definitions to participants as that would taint their view.)*

How do you pick which activities to use? Probe for:

- Criteria used to select activities
- How they prioritize activities within the given time constraints

How do you evaluate student learning? Probe for:

- Sources of evaluations
- When evaluations are created/procured
- How teacher makes sense of results
- If/how instruction is modified in response to results

What follows are excerpts from the answers to the questions (see above) from the pedagogy section of MNSTII from the same teacher used above who taught a lesson on genetics as discussed in the MNSTOI section above. In this paragraph Lars Larson is describing the characteristics of the activities used in his seventh grade science classroom:

> "Punnet squares, percentages and ratios. That's some big math concepts going on...We're talking about these big gigantic words: zygo's, hetero's, homo's, zygo's'. So they have to know language, they have to know math, they have to go over their reading abilities [to read the text]. I had them coloring and drawing in my class. These are art skills...In science class you use a whole bunch of different stuff; you're thrown in a whole bunch of different realms."

When questioned about how Lars evaluates learning, he said:

> " I use scantron/multiple choice tests, worksheets, and practical lab type tests." When probed for an example of a practical lab type test he reported, "identification of birds from a slide show."

Our set of three instruments described above is designed to provide "triangulation" of information on classroom instruction. In particular, the interview instrument can be used to corroborate patterns noted during the classroom observations. These two instruments complement each other to provide a clearer picture of a teacher's practices, knowledge, and beliefs about science teaching when the researcher summarizes data and observations into a written profile. Here is an excerpt from the "Knowing Pedagogy" section of Lars Larson's profile that demonstrates this relationship:

> <u>Appropriate Activities</u>
> He knows that his students are "not really that interested yet in stuff out of a text book. So it [subject matter] needs to be very right there, they can see it." He continues, "They haven't got to the point where just by reading it they can get interested in it." (MnSTII) Consequently, he chooses instructional materials that are within the grasp and of interest to junior high students, such as an article entitled "Insect Munchies" (MnSTOI – insects), videos from the "Eye Witness" series (MnSTOI – insects, post-observation), an a computer simulation program about genetics (MnSTOI – genetics, post-observation).

Some types of information can only be gained through the interview instrument, such as the section on "Developing as a Teacher" as found in the MNSTII. It is not addressed in the CLES 2(20) and is not often observed in the MNSTOI. For the section "Developing as a Teacher" MNSTII asks the following questions:

Table 7

Developing as a Teacher Questions and Prompts:

Have you participated in professional development beyond your university preparation? Probe for:

- meetings, organizations, books, workshops, conferences, mentors

What resources do you use in your teaching and planning that come from outside your classroom?

- school, district, community, state, national

I'm going to ask you to make a pie chart that shows the relative pieces that have contributed thus far to your preparation as a teacher.

- undergraduate courses, graduate courses, books, field experiences, classroom experience, anything else you can think of
- influence of various pieces on their professional growth.

(Comment: It might help to ask the participant to make a list first and then decide the relative impact of each piece.)

Analysis

A teacher profile is developed to summarize teacher data collected from the four instruments described above. Each profile used a similar format, providing descriptions of the participants' teaching in five categories (I-Knowing Science Content, II-Knowing Pedagogy, III-Knowing Students, IV-Establishing a Learning Environment, V-Professional Development) that correspond to our research questions. Also included was a section that described key demographic information about the participants and pertinent contextual elements such as school settings, course information, and community type. A meta-analysis is then completed on sets of teacher profiles. Two categories, elementary science and secondary science, are used for analysis. All profiles within a subgroup are analyzed by a single researcher with knowledge and expertise in the area corresponding to the descriptor for each subgroup. Profile analyses were reviewed and confirmed by two additional reviewers for each set of profiles. A more complete description of this analysis including samples of profile analyses can be found in the second presentation summary, Getting to the Fourth Year: Preliminary Findings Regarding the Practice of MN Beginning K-12 Science Teachers, found elsewhere in these proceedings.

Future Directions

We have currently completed three years of data collection. This year we will add several new teachers to the project and follow others for a second or third year. New participants and follow-up studies continue to raise new questions about teacher practice. At this point, we are satisfied with the instruments and our plan for data analysis.

We believe more work is needed with TRN participants to assure that we have common meaning for terms used in the study. We have learned many lessons about the process of collaborative research and feel it can provide important findings about beginning teachers to the science education community as a whole. Further study is warranted before refined assertions will emerge from the data. Nonetheless, the current results of this study have spawned a wealth of further research questions rich in potential and more focused in scope. We believe that the emerging research will mature into insightful assertions that can help us pursue excellence in Minnesota science teacher preparation.

Authors Notes:

1. Teacher Research Network

These are the researchers who have contributed to the development of the instruments and/or participated in the collection of the data through the 2000-2001-research year.
Some researchers have moved to other institutions since their participation in TRN.
Cyndy Crist, SciMath^{MN} higher education project director; George Davis, Minnesota State University Moorhead and Patricia R. Simpson, St. Cloud State University; TRN co-directors. Researchers are: John Bauman, College of St.Scholastica; David Cline, Saginaw Valley State University; Alice Mae Guckin, College of St. Scholastica; Lynn Hartshorn, University of St. Thomas; Jean Hoff, St. Cloud State University;; Michele Koomen, Gustavus Adolphus College; Carmen Latterell, University of Minnesota Duluth; Robert McClure, St. Mary's University; Jeff Pribyl, Minnesota State University-Mankato; Lon Richardson, Southwest State University; Teresa Shume, Minnesota State University Moorhead; Chery Takkunen, College of St. Scholastica; Tom Tommet, University of St. Thomas; Dorrie Tonnis, West Bend, WI; Kay Wohlhuter, University of Minnesota Duluth.

2. To obtain set of study instruments and protocols send a request on institutional stationary to: Dr. George R. Davis, Regional Science Center, Minnesota State University Moorhead, 1104 7th Avenue South, Moorhead, MN 56560. Questions can be sent to George Davis at davisg@mnstate.edu.

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