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A Flexible K-12 Weather Data Collection and Education Program

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Nebraska Earth Science Education Network (NESEN)

Institute of Agricultural and Natural Resources, University of Nebraska-Lincoln

Introduction

The Nebraska Earth Science Education Network (NESEN) is an organization within the University of Nebraska-Lincoln whose objectives are to: 1) promote and enhance K-12 earth science education in Nebraska, 2) improve teacher knowledge and understanding so that students become better informed about the complexities of environmental and natural resources issues and 3) enhance the transfer of earth science information to the K-12 teaching community (Gosselin, Mohlman, Mesarch & Meyer, 1996; Gosselin et al., 1999). To achieve this last objective NESEN developed the Students and Teachers Exchanging Data, Information and Ideas (STEDII) program with the help of support from the National Aeronautic and Space Administration (NASA) and the Department of Energy's National Institute for Global and Environmental Change (NIGEC). The initial focus of STEDII was to use the collection of weather data as a mechanism to promote the sharing of data and information between eight schools involved in an electronic communication project funded by NASA (Gosselin et al., 1999). The topic of weather was chosen because students experience weather everyday, weather is relevant to students' lives in an agricultural based state (Williams, 1992), weather is quite variable in Nebraska (NebraskaLand, 1996) and weather is part of most school systems'

curriculum. The STEDII project has provided students and teachers with basic weather instrumentation, instruction on how to use these instruments, lessons on weather topics and a website by which schools can share data by submitting and retrieving measurements from a centralized data base.

STEDII is similar to other educational data collection networks. The GLOBE Program (Global Learning and Observations to Benefit the Environment) has students from over 60 countries collecting many different kinds of environmental variables including four types of weather information (Finarelli, 1998). GLOBE (http://www.globe.gov) was initiated to help children appreciate and understand their environment so when they become adults they can make informed and appropriate decisions about protecting and preserving the environment. Quality-assured data collected by the students could then be used to help scientists around the world support their research. One Sky, Many Voices (OSMV), part of the Kids as Global Scientists (KGS) program, is another educational data collection network that focuses predominately on weather in the United States and 5 other countries. OSVM (http://www.onesky.umich.edu/) collects the same weather variables as STEDII and is based on providing students with inquiry tools and resources needed to develop understanding and question specific topics areas in science (Songer, 1996).

Teachers participating in STEDII were asked to describe their personal objectives and vision for the project. The teachers' comments suggest STEDII was used in the classrooms and curricula in many ways. However, NESEN's objectives for STEDII did not necessarily coincide with the teachers' expectations and vision.

This paper presents 1) NESEN's objectives for the STEDII project, 2) fundamentals of the weather project, 3) participating teachers' objectives and 4) approaches used by teachers to implement the project. The paper also highlights some of the similarities in the development and uses of other weather data collection networks and STEDII, but is not intended to be an exhaustive comparison.

A STEDII View from NESEN

NESEN's vision for STEDII is five-fold: 1) create an atmosphere that fosters a dialogue between teachers (and students) to share ideas and teaching techniques that work, 2) show how earth science topics, such as weather, are interrelated with many different disciplines and can be used to teach the disciplines in an applied manner, 3) increase students' understanding of basic weather concepts and climate variability, 4) increase students' understanding of the basics of good scientific research--collecting good data, employing critical thinking skills to determine what is good and bad data and archiving, sharing and displaying data that they have collected and 5) encouraging students and teachers to share the information they have collected with others in their school and community--this promotes a better understanding of earth science topics to a larger audience and provides a sense of accomplishment, pride and camaraderie among the participants.

As the name implies, "Students and Teachers Exchanging Data, Information and Ideas" is a concept designed to take advantage of Internet resources in the context of meeting a teacher's

curriculum objectives. STEDII promotes the sharing of the ideas and teaching methods easily and in a timely manner through fostering an active dialogue between teachers via email and the Internet forum-like pages (http://nesen.unl.edu/discussion/index.html). The study of weather is something that transcends purely the concepts of meteorology. Understanding weather and why it occurs crosses disciplines, such as geography, agriculture, physics and chemistry. Students, for example, investigate the differences in geography of eastern and western Nebraska then translate how these differences affect the local weather. In addition, teaching strategies have also shifted from passive lecture type teaching to more active hands-on styles which are represented by the use of weather instrumentation to collect data (Dewey & Meyer, 2000.) By the intermediate level grades, students should be learning good techniques in data collection and inquiry skills (NRC, 1996). The collection of data and its use crosses into other disciplines such as math and statistics. Summer workshops sponsored by NESEN and NIGEC have been invaluable in presenting ways to teach good data collection techniques for students and teachers. For example, workshop activities required participants to read and record air temperature from thermometers placed at several locations. Participants then compared temperature differences between locations based on calibration of the thermometers and the environment surrounding the thermometer. Next, participants examined temperature differences within a location based on how the participants' read the thermometer and the repetition of measurements at a location.

STEDII Fundamentals

To promote hands-on observation of weather phenomena by students, NESEN provides the following weather instrumentation to participating schools: 1) a **maximum/minimum thermometer** to record the *highest and lowest daily temperatures* during the measurement period (initially liquid thermometers were supplied, but now simple electronic thermometers are supplied); 2) a **rain gauge** to measure liquid *precipitation*; 3) a **sling psychrometer** to measure wet and dry-bulb temperatures to calculate *relative humidity*; 4) a **barometer** to measure *atmospheric pressure* and 5) a **hand-held wind gauge** to measure *wind speed*. The students are asked to design and build their own **wind vane** to measure *wind direction* and make an estimate of *cloud cover*. Photos and descriptions of the instruments provided to the schools can be found at http://nesen.unl.edu/stedii/instrument.htm

The timing of measurements and length of the measurement period are designed to meet the needs of the teachers and students involved in the project. Originally, teachers and students were requested to take weather measurements **every day.** However, this practice became mundane for the students and most teachers had other curriculum objectives that needed to be accomplished, thus making a daily commitment difficult to follow. After an exchange of ideas between the participating teachers and the NESEN staff, a plan was developed to measure data for three two-week periods during the school year to capture interesting weather phenomena. These "focused measurement periods" (FMP) start and end on a Monday. The measurement period is designed to 1) be long enough for an interesting weather phenomenon to occur, 2) provide a long enough period for all students to make measurements multiple times with each instrument, and 3) overlap two weekend periods to show weather does not "stop" on the weekends. The first FMP usually begins at the end of September to allow for variable start of

the school year across the state and an initial instruction period on how to use the weather instruments. The second FMP usually begins at the end of January to allow for school calendar semester breaks. The third FMP usually begins at the middle to the end of April to anticipate the occurrences of Easter, spring breaks and end of school year that varies across the state of Nebraska and particularly between urban and rural schools.

Initially participants were also asked to make measurements as close to noon *(local time)* as possible each day. However, to provide versatility to the teacher and to allow participation by multiple classes at each school, measurements can be taken at any time during the day and time of measurement is part of the data record. Data from one measurement to the next measurement for maximum/minimum temperatures and precipitation represent the high and low temperatures and precipitation accumulation, respectively, for the entire period of time between the measurements. The day before the FMP begins the maximum/minimum thermometers and rain gauges are reset so that the first day's data have a meaningful time frame. Data for wind speed, wind direction, atmospheric pressure, relative humidity and sky conditions represent the weather conditions at the time of the measurement and are not representative of the period of time between the measurements.

A STEDII web page was developed and connected to a database allowing schools to enter and retrieve data at anytime. Data are submitted via the Internet to a password-protected centralized database at the University of Nebraska-Lincoln at http://nesen.unl.edu/stedii/senddata.htm . Values are submitted in metric units. Software used by the data entry program returns messages to the students if data values are outside an acceptable range for the variable. Protocol has been established for coding missing data values when data is submitted to the database. Data can be retrieved in metric or english units at http://nesen.unl.edu/stedii/getdata.htm . A map of all the schools' locations is provided at http://nesen.unl.edu/stedii/schoolmap.htm and some of the schools have provided descriptions of the surrounding area where their data was collected. A summary of the data collected by participating schools can be found at http://nesen.unl.edu/stedii/gdsummary.htm

A set of lessons for each FMP were collaboratively developed by a pre-service teacher at UNL, an in-service teacher (who was participating in STEDII) and the NESEN staff. The first set of lessons is designed to let students investigate simple weather principles while learning how to use the instrumentation provided to them. The second set of FMP activities examines topographical and geographical concepts that are related to weather. A final set of FMP activities introduces the students to concepts ranging from the greenhouse effect and global warming to forecasting weather in the electronic age. One set of activities for each FMP was developed for elementary students and one for intermediate/high school students. FMP activities were designed based on age appropriate concepts dictated by the National Science Standards (NRC, 1996) and the Nebraska Science and Mathematics Frameworks (NDE, 1997). Nebraska frameworks addressed by the STEDII project are found in Table 1. These lessons are only suggestions and starting points for teachers, while the data collection is something that is to be consistent across schools. Hard copy versions of each of the lessons were provided to the schools and electronic versions were later added to our web site. (http://nesen.unl.edu/activities/meteorclimate.html)

Table 1

Examples of Nebraska State Frameworks that can be achieved by using the STEDII weather project

Discipline	Nebraska Framework Rubric	Description
Mathematics	4.3.1 (4.3.2)	"By the end of the fourth grade, students will estimate, measure and solve problems using metric (standard) units for linear measure, area mass/weight and capacity. – Measure and read temperature accurately to the nearest degree using Celsius (Fahrenheit) thermometer.
	4.5.1	"By the end of fourth grade, students will collect, organize, represent, and interpret numerical and categorical data and clearly communicate the findings. – Collect, construct, and interpret data in line plots, tables, charts, and graphs, such as pie graphs, bar graphs and pictographs."
	8.5.2	" By the end of the eighth grade students will read and interpret tables, charts, and graphs to make comparisons, predictions and inferences. "
Science	4.2.1	"By the end of the fourth grade, students will develop the abilities needed to do scientific inquiry. – Employ simple equipment and tools to gather data and extend the senses."
	4.5.2	By the end of the fourth grade, students will develop an understanding of objects in the sky – describe and observe how objects move in patterns, such as sun, moon, stars and clouds."
	4.5.3	"By the end of the fourth grade, students will develop an understanding of the changes in the earth and sky. – Describe changes in weather using measurable quantities, such as temperature, precipitation, and wind direction and speed."
	8.2.1	"By the end of eighth grade, students will develop the abilities need to do science inquiry.- Use appropriate tools and techniques to gather, analyze, and interpret data."
	8.5.1	"By the end of the eighth grade, students will develop an understanding of the structure of the earth. – Investigate and describe major impact of topography, location and ocean on climate."
	12.5.1	"By the end of the twelfth grade students will develop an understanding of energy in the earth system. – Investigate and explain how global climate is determined by energy transfer from the sun and its influence by dynamic processes, such as cloud formation, and the earth's rotation and static conditions, such as the position of mountain ranges."

Initially in 1995, STEDII began with eight schools (grades 5-12) across Nebraska with the same level of Internet connectivity (Gosselin et al., 1999). By the beginning of 1999, the project had blossomed into a program that had reached 55 schools and grade levels ranging from 3rd to 12th

grade. An "Earth System Science for Educators" class at the University of Nebraska-Lincoln (UNL) (course number SNRS 299a) has also participated. In the four years that STEDII has existed, the flux of teachers, schools and curriculum standards has caused the number of participants to fluctuate from year to year. At the peak of participation during the fall of 1997, thirty-three schools and over 2500 students actively took part in the program. Of the 55 schools, 24 schools have collected data for four FMPs. Five schools have collected data for all eight measurements periods and several schools collect data everyday for the entire school year. Of these 24 schools, 11 teachers initiated the STEDII program in their schools.

The exchange of data and information was introduced by the NESEN staff by pairing schools based on geographical location (e.g., a northern school paired with a southern school or a eastern school paired with a western school.) Before each school year started, all schools that had been part of STEDII were contacted to check their anticipated level of participation for the upcoming school year. These schools were pooled together to develop the paired groupings. The year that the science education class at UNL participated, students in these classes were coupled with one or more of the paired groups of schools to share data and dialogue about educational methods.

STEDII Survey

Teachers were asked to complete a phone survey on the implementation and importance of components of STEDII and use of data in the classroom. To participate in the survey, teachers needed to meet three criteria: 1) actively participate in the FMPs during the 1998-1999 school year, 2) participated in at least four previous FMPs and 3) be the original teacher to initiate STEDII in their school. Eleven teachers meet the criteria. Each teacher was asked to participate in a phone survey after they received an email containing the survey questions. All teachers participated in the phone survey. The schools represent both urban and rural schools, public and private schools, small and large class size and elementary, intermediate and high school classes. A summary of the subject area, grade level and class size by school is found in Table 2. The eleven teachers had contact with approximately 500 students during the 1998-1999 school year. Eight of the 11 teachers had participated in a workshop related to STEDII and/or data collection sponsored by NESEN.

Table 2

Surveyed schools involved in the STEDII project, class disciplines taught in the classroom, grade level and number of students in the classroom(s)

School	Class Topic	Grade	Class Structure/Total Students
School 1	Earth Science	Seventh	20-25 students in 3 classes Total: 70
School 2	Earth Science & Life Science	Seventh & Eighth	18 students in one class
School 3	Earth Science	Ninth	21 students in 4 classes Total: 84

School	Class Topic	Grade	Class Structure/Total Students
School 4	Earth Science	Eighth	20-22 students in 4 classes Total: 85
School 5	Earth Science	Ninth (& Seventh)	9 students in 5 classes Total: 45
School 6	General Science	Seventh	15-18 students in 3 classes Total: 48
School 7	Environmental Sciences	Eleventh & Twelfth	8 students in one class
School 8	General Science	Eighth	15 students in two classes Total: 30 students
School 9	General Science	Fifth	25-28 students in 3 classes Total: 80
School 10	Earth Science	Eighth	11 students in one class
School 11	General Science	Ninth & Tenth	10 students in one class

The following questions formed the basis of the survey:

1) How do you make STEDII work? Describe how your class proceeds in collecting, recording, comparing and sharing data.

2) How do you use data that has been collected?

3) Are there certain aspects/components of STEDII that you consider more important than others?

Because of the question-type format, anecdotal information was obtained from the teachers about their participation and implementation of STEDII. This type of assessment does not lend itself to numerical analysis.

At the time of the survey, all of the teachers had at least one computer in their classroom that had Internet connectivity. However, when some of the schools initiated the STEDII program there may have been only one or two Internet-capable computers located in other classrooms or the library for the entire school.

A STEDII View from the Teacher

Almost all of the teachers surveyed agreed that there were three main objectives for participating in STEDII. First and most importantly, they wanted students to learn basic weather principles including how different variables are measured and how the variables are related. The STEDII activity of simple measurement of weather variables helped defined what factors are considered weather and how they are related to each other. For example, relative humidity is related to

temperature and was calculated based on two different temperature measurements [wet- and dry-bulb temperatures]. Second most important, teachers wanted students to learn how to take data, develop good research techniques and critical thinking skills. STEDII provided students with a way to actively observe and collect weather information instead of passively learning by using data in books or databases. Students started to determine whether data was "bad" or "good," and they began to develop their own hypotheses and test these hypotheses. Third most important, teachers wanted a good first contact to the Internet for their students (and sometimes for the teachers themselves). As part of the STEDII project, they became part of a state-wide community and used the Internet to send their own information to the centralized database. They also found the NESEN website to be a good conduit to weather information in cyberspace.

Although all the teachers recognized the powerful potential of the project to share data and ideas between themselves, only a few capitalized on that opportunity. The idea of pairing schools on a geographical basis was not effective. Often one school in the pair would not participate during a FMP and the sharing of data did not take place. In most cases, the teachers surveyed wanted to share information, but they did not have the time. They would like to become more interactive, once they find the time to apply this aspect of the project to their curriculum and assess the learning achievements of the students. This lack of program development time is consistent with teachers in the GLOBE and OSMV projects (Lee & Songer, 1999; Means, 1998a; Means, 1998b). First-time participants in educational data collection programs tend to focus on getting the activities done and build upon the project later (Kam & Songer, 1998). However, teachers inspired positive student interest in the STEDII project by using the connectivity concept of STEDII. When students saw they were part of a project with other schools across the state, the students wanted to collect good data and participate on the same level as other schools. Creating an active dialogue between teachers (and students) would work better if the web dialogue utility were directly incorporated into the project. The OSVM project has a very active dialogue area which is integral to the first phase of their yearly program (Lee, Songer & Samson, 1998).

The remainder of this paper looks at the method of collecting data in the classroom designed by the 11 teachers and how their students use these data.

Teaching the Art of Data Collection

The teachers' second most important vision for the STEDII project was teaching their students how to collect data. All teachers taught their students how to use the instruments, record data and use the web page to submit data to the database prior to the first FMP. The amount of class time spent on this orientation varied depending on when weather was going to be taught. If a teacher's curriculum involved weather topics later in the school year then they would spend only a short time in the Fall on how to use the instruments. Some teachers would then have short "brush-up" measurement technique lessons prior to the Winter and Spring FMPs.

Once the technique of data collection was presented, the actual method of data collection at each school varied between schools involved in the project. This was also found when evaluating the GLOBE schools (Means, 1998b.) Some common themes existed based on class size.

Small Classes

For classes with fewer than 12 students, all students were instructed on how to use each instrument to collect data, but one or two students would take data with the same instruments during the entire measurement period. Some schools used "swing" students, who were familiar with all the instruments, as a substitute to take measurements if one of the regular data collectors was absent on a particular day. Another teacher had two students take the same measurements so that if one student was absent the other student was responsible for the measurement to be taken. One teacher asked the students to rotate through all the measurements during the FMP, but students asked to continue taking the same measurement for the whole period. This teacher found this data collection technique to be a more efficient use of class time because students needed five minutes at the beginning of each class period to conduct the measurements.

Large Classes

Teachers with large classes of more than 15 students tended to divide the class up into groups of two, three or four students. Once in groups, the students' roles varied between schools. Some teachers had one of the students in a group make a measurement and another group member recorded the data value. Other teachers had all the students in a group make measurements and provide an average of their results. One teacher had several learning disabled students in the class, so the teacher always paired these students with other students so they could help each other. Some teachers had several students use the instruments to measure data and others student find data values from other resources, like the Internet. Several schools also had an automated, electronic weather station, so half of the students in the group made measurements with the hand-held instruments and the other half recorded data from their electronic station. Most schools would also have one group of students responsible for submitting the collected data via the web page. One teacher had several students who were more computer literate than other students in the class, so one of these students was always part of the data submission group.

Once the group had several days of experience making a measurement, they moved on to another measurement. Some teachers had the entire group move from one type of measurement to another. Other teachers had one student rotate out of a group at a time into the next group, thus some commonality in the group allowed students to help each other remember how to use the instrument to make measurements. This collaborative learning and students teaching other students to use the weather instruments is a similar practice used in OSMV (Kam & Songer, 1998).

Independent of Class Size

A few other data collection patterns were present. One teacher taught all the students to use all the instruments. Then the teacher had a sign-up sheet for the students to take measurements each day at noon in order to have all their data collected at the same time each day. Another teacher used a similar idea. After the first FMP was completed and weather was no longer taught in the classroom, the teacher went to the seventh grade study hall and asked if any students would be interested in helping out. The teacher taught these new students how to use the instruments and then they signed up to take data during other times of the year.

A Webbing Experience

Although the use of the Internet as a medium for teacher information exchange and data exchange did not meet the NESEN staff's vision, it did have a positive effect on the students. As their schools came on-line and they became part of the STEDII project, many teachers commented that it was a good first contact for students with Internet technology. Data entry pages were simple to use and the students could immediately see their data on the data retrieval web page. Even though many teachers had not used data from other schools yet in their lessons, when the students saw their school's name along with other school names it created a surprising effect. One teacher said, "Entering data on the web gives the data some legitimacy because it is going to the university. They [the students] are excited about it [the STEDII project] because it must be important." Another teacher added, "You could have the same kind of project in the classroom, but when you take it to the web, it kind of validates the data. It increases the importance of the data....Other schools are doing the same thing so it must be good." Inter-school competition becomes a factor as one teacher said, "They [the students] also noted that some of the other schools they compete against in sports were taking more data than they were, so they were more enthusiastic about taking data." Data quality tended to improve as one teacher said, "They are excited that other schools are going to use their data. They know it is going to be used, so they become a little more accountable." Teachers have also found the Internet to be a great resource. One teacher noted, "By taking weather data, the students have become more aware of other sources of weather data...the TV, the radio and the newspaper. I have them look up articles about weather and related news stories [on the Internet]." Another teacher also had students use the Internet to find other data, especially when they might be missing one of their data values.

Using the data

Each teacher has various ways that they use the data in their classroom. Since not every teacher is strictly teaching weather, the data can be used in other disciplines and sometimes data even gets used outside the classroom. One teacher found that when students started taking data especially in the Winter FMP it was one of the first times the fifth graders had worked with negative numbers, so it helped in their math lessons. Another teacher used the data in math lessons as input for converting from English to Metric units. One teacher said that occasionally athletic coaches came into the classroom and asked the students what the weather was like and how it might affect their practices.

Most participating schools' students took pride in their data collection and active learning. During one in-school science fair in which parents view the final projects, students picked something that would show the signs of spring arriving in their local area, such as certain flowers blooming or birds arriving in the area. These students also graphed maximum and minimum temperature during this time period to see if there were any relationships. A teacher associated with this activity said, "Since it is data that they actually collected, it gives them more ownership and they want to make sure they get it right since they are presenting it. They are not as interested when it is data that comes out of a book as when it is their own data."

Another teacher had the students keep a journal of a qualitative discussion of the weather during a FMP. After the FMP, the class compared the students' journal entries and the data to see how

well they agreed. The teacher also had the students bring in weather information from home during the FMP and they tried to predict the weather for the next day based upon their observations.

One teacher, who does use all the participating STEDII schools' data, has students plot atmospheric pressure graphs from data they can get from other schools and other Internet resources. Several schools that have access to an automated electronic weather station at their schools used the electronic data as a check to compare the hand-collected data. Students do not just accept the weather stations data as being correct, but look at these data with a critical eye.

Conclusions

The STEDII weather project was created with visions of learning about weather, learning how to collect data and sharing data and ideas about teaching between teachers. Realizing the logistics of the classroom, teachers and students, the NESEN staff developed the STEDII project with enough flexibility that the participating teachers have been able to tailor the project to fit their needs. This flexibility was also built into the GLOBE and OSMV projects. (Lee & Songer, 1999; Finarelli, 1998) The teachers surveyed felt that STEDII was an integral part of their curriculum. We found that the teachers had a vision of STEDII that shared some of the same objectives as NESEN, but the importance of some objectives weighed more than other objectives. We also found that some visions that NESEN hoped to inspire were not easily obtainable. Although the teachers have not to a large extent tapped into the project's ability to share these data and create a dialogue, they have used STEDII as a tool to pique student interest in earth science by showing the students how they can communicate electronically across their state and learning what it means to collect data as part of a larger project.

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