Understanding and Using Science Process Skills by 3rd and 4th Grade Students

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Abstract

The Iowa Chautauqua efforts were undertaken over a period of two decades with major funding from the National Science Foundation to improve both college and K-12 science teaching. A vital part of this research effort has been locating teachers to help determine changes in their teaching of science. The study involves a full academic year of Chautauqua K-12 teaching and focused only on third and fourth grade students at two different Chautauqua sites. The study focuses on student successes in using and understanding six science process skills when taught by Chautauqua vs Control Teachers. There are *significant* differences in the actions and participation of students in Chautauqua taught classrooms compared with students in Control classrooms.

Keywords: science process skills, early elementary, collaborative learning

Iowa Chautauqua

Iowa was one of the sites chosen by the American Association for the Advancement of Science (AAAS) for their year-long Chautauquas designed to improve college science teaching. These Chautauquas were aimed at upgrading the content used by faculty from non-research universities and community colleges. Even before the Iowa Chautauqua programs for college teachers were completed, science educators in Iowa decided that the model for improving college teaching was so impressive that it should be used for K-12 teachers as well. This Iowa program was unique in that it consisted of year-long efforts to replace *typical* professional development programs offered for K-12 teachers. They usually consist only of a brief summer workshop.

The Chautauqua Professional Development Programs for K-12 teachers consist of a year-long series developed and approved by the National Diffusion Network (NDN; 1993). They consist of five features for Iowa Chautauquas operating at two sites across the State each year and include the following features:

↓ ***Annual Leadership Conferences at Each of Two Chautauqua Sites for one week in early June***

Support Panels organized at each site are Chaired by the Project Director and
Co-chaired by representatives of two regional Area Education Agencies (AEA).

Participants Include:
Two New Teacher Leaders each year from all three grade levels
(elementary, middle, and high school)
Several of the most successful Teacher Leaders from past efforts
At least one K-12 School Administrator
An experienced Ph.D. student with research expertise (assisted by MS students)

Actions for Support Panels:
Selecting Control Teachers
Select the content "Domain" for primary focus for each new-year
Indicating specific reforms for science teaching
Establishing specific calendar dates for Workshops and Short Courses

↓ ***Two 2-Week Teacher Leader Workshops (June or July)***

Reporting on most successful reforms advocated in the National Standards
Consider major needs for accomplishing current reforms
Interactions among teachers from the two focus grade level groups
Illustrating current reforms from other research reports
Teaching plans to be tried for at least 5 consecutive days with students
Major past experiences and outcomes to share with new students
and teachers
Use of cross-cutting concepts and core ideas

↓ ***Fall Short Courses at each Site in October for a Thursday, Friday, & Saturday***

Sharing teaching experiences
Identifying evidences of successes
What went wrong and why?
Sharing new ideas for reform efforts
Teaching plans for 4-6 weeks to share with others in April

↓ ***Spring Short Courses in April for a[Thursday, Friday, & Saturday***

Share data to indicate successes and failures
Urging continued use and understanding of new ideas
Sharing new ideas for future teaching efforts
Identify two Area Education Agencies for the next year
Identify three new Teacher Leaders for the next year
Defining more needed changes in science teaching
Selecting content "Domain" focus for the next year
(i.e., Concepts, Processes, Creativity, Attitude, Applications, or Worldviews; McCormack & Yager, 1989)

→ **Application of Results Shared with Whole Communities (Saturday P.M.)**

Celebration luncheon
Showcasing exciting student accomplishments
Students indicate their use and understanding of selected content Domain
Attendees include parents, school administrators, school board members, teachers, local scientists, and community leaders
Local media invited to publicize student accomplishments

The Iowa Chautauqua Programs were developed and successful over a period of more than two decades with National Science Foundation (NSF) funding (2005). Funds were used to support staff members and teacher enrollees involved with the Chautauqua Program. The staff members were dedicated to improvement of science teaching and improved student learning, as well as successes and failures with using science process skills. Many argue that these skills are central to current reform efforts. The major focus of this research effort is the use and understanding of six science process skills involving third and fourth grade level students.

Science Process Skills

The identification of science process skills to be included in science courses was undertaken by prestigious scientists in the 1980s at the same time Chautauqua efforts were underway. There have been few objections to the importance of their being a focus for improving science teaching and student learning. But very few teachers have really defined or used them to indicate student learning successes. Nor have they been important for use and understanding of science generally in K-12 science classrooms. Scientists were the first to propose the use of such skills as teaching goals and new ways of defining successes and/or failures for improving student learning.

The Iowa Chautauqua Professional Development Programs began for K-12 classrooms across the State just as major funding for Science: A Process Approach (SAPA) was implemented. SAPA was a reform effort developed by an impressive group of over twenty-five scientists and leaders who were brought together by the American Association for the Advancement of Science (1963) with major National Science Foundation funding. Early efforts with SAPA resulted in more than thirty boxes of instructional materials for students for science learning in kindergarten through sixth grade. In 1964, Arthur H. Livermore, as Deputy Director of Education for the Commission on Science Education, proposed stimulating the use of science process skills for teaching in all elementary grade levels. But, Livermore's final statement was: "even though SAPA was more effective than traditional teaching methods, the program never achieved the market penetration that had been hoped after twenty years of efforts" (Abstract, 1).

The six process skills identified by the SAPA leaders were seen as appropriate for all K-4 grade level students. These *first* six process skills include: Observing, Classifying, Measuring, Communicating, Inferring, and Predicting. The Commission also offered six more *complex* science process skills which were created for upper elementary and middle school students for measuring student learning. All twelve continue to be used today as examples of needed reforms for all grade levels. Livermore and his associates defined all twelve science process skills in their final report. They also included examples of each of the skills (1964). All remain a focus for educators today. The twelve science process skills and examples of each consist of the following:

- **Observing –** using the senses to gather information about an object or event. *Example*: Describing a pencil as yellow.

- **Classifying –** grouping or ordering objects or events into categories based on properties or criteria. *Example*: Placing all rocks having certain grain size or hardness in group.

- **Measuring –** using both, the standard and non-standard measures, or estimates to describe the dimensions of an object or event. *Example*: Using a meter stick to measure the length of a table in centimeters.

- **Communicating --** using words or graphic symbols to describe an action, object, or event. *Example*: Describing the change in height of a plant over time in writing or through a graph.

- **Inferring –** making an "educated guess" about an object or event based on previously gathered data or information. *Example*: Saying that the person who used a pencil made many mistakes because the eraser was well worn.

- **Predicting –** stating the outcome of a future event based on a pattern of evidence. *Example*: Predicting the height of a plant in two weeks-time based on a graph of its growth during the previous four weeks.

SECONDARY SIX:

- **Controlling Variables --** being able to identify variables that can affect an experimental outcome, keeping most constant while manipulating only the independent variable. *Example:* Realizing through past experiences that amount of light and water need to be controlled when testing to see how the addition of organic matter affects the growth of beans.

- **Defining Operationally** – stating how to measure a variable in an experiment. *Example:* Stating that bean growth will be measured in centimeters per week.

- **Formulating Hypotheses** -- stating the expected outcome of an experiment. *Example:* The greater the amount of organic matter added to the soil, the greater the bean growth.

- **Interpreting Data** – organizing data and drawing conclusions from it. *Example:* Recording data from the experiment on bean growth in a data table and forming a conclusion which relates trends in the data to variables.

- **Experimenting** – being able to conduct an experiment, including asking an appropriate question, stating a hypothesis, identifying and controlling variables, operationally defining those variables, designing a "fair" experiment, conducting the experiment, and interpreting the results of the experiment. *Example:* The entire process of conducting the experiment on the effect of organic matter on the growth of bean plants.

- **Formulating Models** – creating a mental or physical model of a process or event. *Example:* The model of how the processes of evaporation and condensation interrelate in the water cycle. (Livermore, 1964, p. 273)

Interestingly, the science process skills identified student explanations as a way of students "doing science" personally. Science is defined by the National Science Teachers Association as "consisting of the exploration of the natural universe seeking explanations of the objects and events encountered" (NSTA, 2013-14, p. 227). Few have objected to the importance of the science process skills that were offered by prestigious AAAS scientists involved with SAPA! But, few really focus on them in meaningful ways of accomplishing student learning (especially for high school teachers)!

The Full Options Science System (FOSS) is another reform effort developed for elementary level students at the Lawrence Hall of Science at the University of California, Berkeley. It was developed with four separate National Science Foundation grants beginning in 1988, five years after SAPA funding ended. The FOSS program remains in operation and is being funded for a fourth edition entitled, FOSS Next Generation 2014-2015. Perhaps FOSS is still alive and accomplishing success because it has a broader view of what people wanted to experience in terms of student thinking as well as inclusion of both concepts *and* processes. For more than twenty-five years, FOSS has worked in classrooms to define *how to teach* the practices of science and engineering together with major concepts of science.

FOSS uses concepts, as well as process skills, as organizers. Examples of FOSS modules include: Air and Weather; Insects and Plants; Solids and Liquids; Fabrics; Motion and Matter; Electronics; Mixtures and Solutions; Materials in our World; Human Brain and Senses; and Structures of Life. Studies focusing on SAPA and FOSS indicate that elementary school students can use process skills meaningfully. They also retain them for future use outside the classroom.

Some Chautauqua teachers choose to develop their own "boxes" to indicate reform efforts with student use of projects in classrooms as well as outside the classroom. Such emphases are characteristic of the teaching of teachers enrolled in a year-long Chautauqua program!

Using Chautauqua Sequence

The Iowa Chautauqua Programs have offered successful ways to achieve new reforms. It is now important to identify persons involved and their roles in a year-long effort at two Iowa Chautauqua sites for a recent year indicating student use and understanding of science process skills. The five features include: A one week Leadership Conference; Two 2-week Teacher Leader Workshops; Fall and Spring Short Courses (for three days each); and Application of Results Shared with Others.

The AEAs are vital constituents because of their role in selecting the Control Teachers at each Chautauqua Site. The AEAs are regional organizations in Iowa dedicated to the improvement of student learning. Control Teachers are not significantly different from Chautauqua Teachers in terms of age, gender, and having at least four years of teaching experience but no more than ten years.

The key to success is the involvement of several of the *most successful* Teacher Leaders from past workshops and their indication of specific needed reforms in science teaching. Specifying which content "Domain" becomes the primary focus for new-year efforts is another major function of a Support Panel as well as selecting specific calendar dates for workshops and short courses across the academic year.

The two two-week Teacher Leader Workshops (June or July) provide the coming together of Teacher Leaders at the two different sites for all three grade levels (elementary, middle, and high school).The teachers interact with one another and discuss their own experiences and reform outcomes about teaching. Lesson plans are developed to use for at least five days with their students during the fall semester. The plans are developed to exemplify the "Desired" reform features of teaching for the chosen content "Domain" identified. The specific Domain for this research effort involves the use and understanding of six science process skills by third and fourth grade level students.

The Fall Short Courses held in October are for discussions among teachers of how to indicate their successes/failures with students with their five day plans. New plans are then developed for use during a 4-6 week period during the next semester. Teachers discuss what went wrong with their plans and why some plans did not work. The Teacher Leaders often share ideas and solutions to problems from their own teaching experiences.

The primary persons involved in the final April Short Courses are students and Teacher Leaders who share their experiences and often share new ideas for teaching and evidences of successes. Students are observed on Fridays during science class periods. Other actions undertaken at the final Spring Short Courses are the identifying of *two new* AEAs for the next year, identification of *new* Teacher Leaders, and selection of the content “Domain” for future Chautauquas.

All students are invited to a “Celebration Luncheon” Saturday afternoon at the two sites to showcase their use and understanding of the six science process skills. The students are encouraged to demonstrate the science process skill(s) they experienced as best, either as a group or individually. They are also asked to indicate which science process skill(s) they found most difficult to use, understand, and relate personally.

School administrators, teachers, parents, local business people, community leaders, and others interested in reform efforts are invited to attend the Saturday afternoon sessions and to observe student learning first-hand. Local media are invited as a means of reporting student projects to the whole community through local newspapers and/or newsletters.

The organization of Chautauqua Programs continues to be used today for the improvement of science teaching and student learning. The Chautauqua organization for this research emphasizes the collected observations of third and fourth grade students at two different Iowa Chautauqua Sites over a period of one year. The observations were collected from parents, school administrators, school board members, community leaders, teachers, high school students, and even some local scientists. Following are the two Research Questions central to this research effort.

Research Question One

Research Question One focuses on students’ use and understanding of the six science process skills when taught by Chautauqua vs Control Teachers. Specifically, it states, “How do percentages differ for third and fourth grade students in using and understanding science process skills when taught by Chautauqua teachers vs those taught by Control teachers at two different Chautauqua sites over a full year?”

Procedures

Students are encouraged to define the six early process skills and to use them in the classrooms and in their personal lives. Students are reminded of the six process skills and the definition of each skill (observing, classifying, measuring, communicating, inferring, and predicting) which is to be used throughout the school year. Students are asked to choose one or two skills they would like to use and understand more. Some of the following questions were used to help get students thinking about the different skills. Could you give a better example of the process skills? How could the process skill(s) be used in their daily lives, at home, and in the whole community? What are some projects which can involve the whole class? What projects could small groups of students do on their own? What are some examples of how the skills could be used in/outside the classroom? Students are encouraged to lead class discussions and involve other students in debating their differences in using and understanding the different process skills. Teachers encourage students to use the process skills in other facets of the curriculum during the school year. Students even welcomed arguments concerning the use and understanding of different process skills. Some students here thought one skill meant one thing while other students thought it could mean something altogether different. *This causes more discussion!*

More time is spent on defining the use and understanding of some of the skills to help get students more interested in science and wanting to explore more about the natural world and to explain the objects and events encountered. Elementary teachers often ask for advice from middle and high school teachers on what could be done to encourage their students to use the process skills in different ways and to help better understand the meaning of each skill. The use and understanding of the science process skills indicated by students over the whole year is what is reported at the April Short Courses to exemplify the Chautauqua Model. Teachers frequently encourage students to use and understand the science process skills for personal use and not just something for them to repeat from textbooks and laboratory manuals as features in typical tests.

Results

Table 1 indicates the percentages of students who were observed using and understanding the six simple process skills. This study indicates significantly higher use of the skills by Chautauqua taught students vs students taught in Control classrooms. Table 1 shows that out of 144 students enrolled in the Chautauqua classrooms, 97% displayed the use and understanding of the *observing* process skill, while only 30% of the 96 students in the Control classroom displayed the use and understanding of this skill. Similar percentages are shown indicating the use and understanding of the other five science process skills.

Assuming the students are representative of all such students, e.g. Chautauqua vs. Control taught students, chi-square tests were used to determine if the students of Chautauqua vs Control taught students at two different Chautauqua Sites. Significant differences appeared in their display of the use and understanding of the six science process skills. Table 1 indicates the percentage of differences between the students at two different Chautauqua Sites. The level of significance for each comparison was at the 0.001 level.

The observations of students were rated to calculate the percentages of students using and understanding the six science process skills: 1 = excellent (indicating that almost all of the students understood and used each of the skills); 2 = some experience (indicating that some of the students understood and used the skills to some degree); 3 = marginal (indicating a few of the students really understood and used the skills); 4 = No (indicating that hardly any of the students understood or used the skills). The calculated percentages indicate the use and understanding of the six science process skills involving both the Chautauqua and Control taught students.

The results for Research Question One emphasize student improvements in the use and understanding of the science process skills as indicated in Table 1.

Table 1
Percentages of Third and Fourth Grade Students Using and Understanding Science Process Skills when Taught by Chautauqua Teachers vs Those Taught by Control Teachers from Two Chautauqua Sites

	Chautauqua Teachers	Control Teachers	z	P
Site 1				
Processes Skills Used by 3rd and 4th Grade Students				
Observing	97	30	11.31	0.001
Classifying	74	l6	8.923	0.001
Measuring	86	31	8.786	0.001
Communicating	91	36	9.167	0.001
Inferring	59	9	7.862	0.001
Predicting	87	24	9.937	0.001

Chautauqua Teachers 8; Students 144
Control Teachers 6; Students 96

	Chautauqua Teachers	Control Teachers	z	P
Site 2				
Processes Skills Used by 3rd and 4rd Grade Students				
Observing	93	21	10.709	0.001
Classifying	77	l2	9.312	0.001
Measuring	87	32	8.234	0.001
Communicating	93	28	9.851	0.001
Inferring	52	8	6.656	0.001
Predicting	83	25	8.455	0.001

Chautauqua Teachers 7; Students 125
Control Teachers 6; Students 87

Figure 1 illustrates the differences in percentages of third and fourth grade students observed using and understanding the six simple science process skills at two different Chautauqua Sites in both Chautauqua and Control classrooms over a full year of effort. The observation sites are identified in Figure One as Chautauqua Sites One and Two.

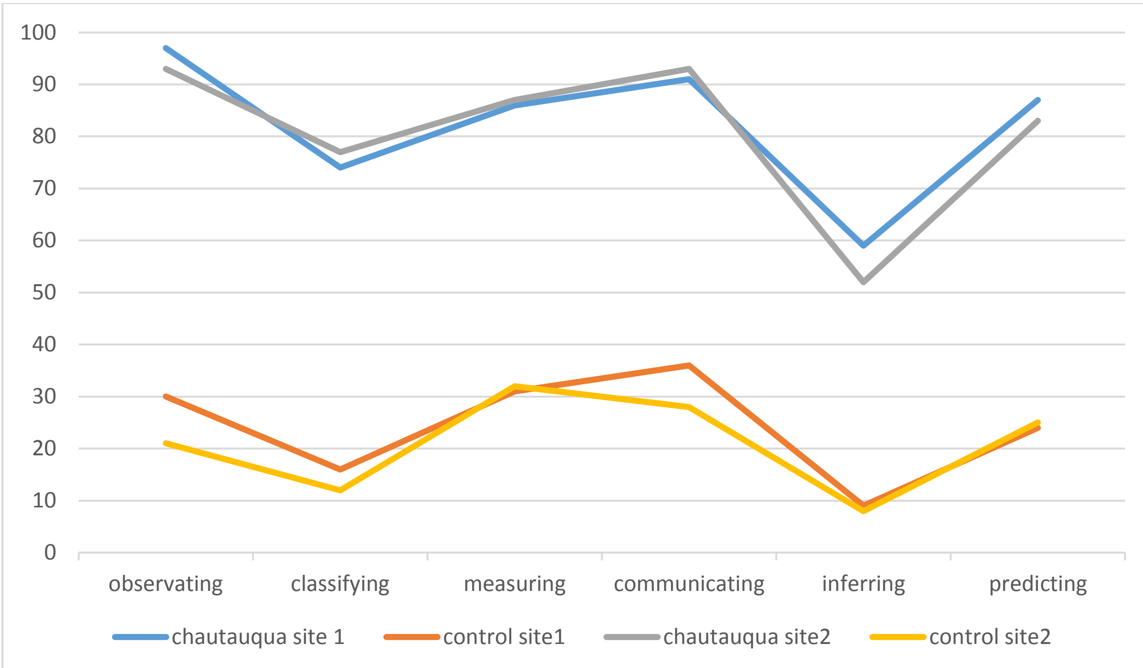

Figure 1. Differences in percentages of students using and understanding the six process skills at Chautauqua sites one and two.

The results at Chautauqua Site 1 indicate student use and understanding of the *observing* process skill. It was 97% in the Chautauqua classrooms; but, only 30% of students in the Control taught classrooms indicated their use and understanding of *observing*. The use and understanding of the *classifying* process skill by students was 74% at Chautauqua Site 1 involving Chautauqua taught students. However, only 16% of students in the Control classrooms indicated their use and understanding of the *classifying* process skill. Figure 1 indicates that 86% of the students enrolled at Chautauqua Site 1 used and understood the process skill of *measuring* in Chautauqua classrooms**,** while only 31% of the students in the Control group indicated their use and understanding of *measuring*. The *communication* skill observed in Chautauqua classrooms indicates that 91% of the students enrolled at Chautauqua Site 1 used and understood this skill, but, only 36% of the students in the Control classrooms were seen using and understanding *communication*. The use and understanding of the process skill of *inferring* was indicated by 59% of the students enrolled in the Chautauqua classroom at Site 1, but, only 9% of the students in the Control classrooms. The use and understanding of the *predicting* process skill was indicated by 87% of the students enrolled in the Chautauqua classrooms observed at Site 1, while only 24% of students in the Control classrooms were observed as using and understanding the *predicting* skill.

As seen in Figure 1, the percentage of students enrolled in the Chautauqua classrooms at Chautauqua Site 2 are also significantly higher in their use and understanding of all six science process skills than students enrolled in Control classrooms.

Research Question Two

The second research focus for this study deals with student actions in classrooms. More specifically, Research Question Two is, "How do actions of third and fourth grade students at the two sites differ in classrooms regarding science process skills when taught by Chautauqua teachers vs those taught by Control teachers?"

Procedures

The teachers and students involved in Research Question Two are the same as those involved in Research Question One and take place at the same two Chautauqua Sites during the same academic year. The observations are from other teachers, administrators, parents, high school students, as well as members of the Support Panels at the two different sites. The Chautauqua students were encouraged to question ideas, try out their ideas, explore, collect information, review and revise conclusions based on evidence. The following examples are questions suggested for teachers to use to help get students interested in thinking about science and the six process skills. These include: 1) questions that describe what you did; 2) questions that predict what you will do next; 3) questions that relate to situations with others; 4) seeking explanations on what caused something to happen; and 5) seeking advice that leads you to believe what happened. The observations indicate discussion and debate among students. Students were encouraged to share their discoveries with other students and engage in debates with others. Questioning of students is a way to encourage and assess student learning. It provides evidence of continuous efforts. Involvement of others outside the classroom was a way of continuing debates on the process skills as well as a learning tool for students. These questions were to promote student thinking and not simply used by students for "remembering" what occurs as in typical Control classrooms. Chautauqua taught students are encouraged to do hands-on projects and to learn by exploring and not just from reading and remembering something from textbooks or laboratory manuals.

Results

Table 2 is a report of different actions observed by third and fourth grade students taught by Chautauqua teachers vs students taught by Control teachers involving two sites. As indicated, there is significantly more student involvement and participation in the classrooms taught by Chautauqua teachers. The differences tabulated are from the observations reported by teachers, administrators, parents, and even high school students at the final April Short Courses. Support Panel members were also invited to report on their classroom observations. The Control students were more often exposed to factual and recall experiences from text materials, with little or no time provided for exploring, testing, questioning, or other methods featured by discovery learning.

Table 2

How do Student Actions of Third and Fourth Grade Students at the Two Sites Differ in Classrooms Regarding Science Process Skills when Taught by Chautauqua Teachers vs Those Taught by Control Teachers

A. Observations of students in classrooms taught by Chautauqua teachers:

Sharing ideas with the teacher
Sharing observations with other students
Negotiating/sharing and refining ideas
Defending responses with evidence
Responding to teacher questions
Asking questions
Providing explanations for phenomena
Collaborating with other students both inside and outside the classroom
Elaborating on what the teacher says
Students making their own observations beyond those planned by teachers
Searching for resources
Using resources (unsolicited)
Offering ideas for approaching problems
Bringing in resources to study
Using alternative forms of communication
Making their own observations
Communicating data with other students
Recognizing errors in their initial ideas
Designing experiments with other students
Offering new ideas and procedures for next step actions
Movement across whole classroom
Using experience in outside community activities

B. Observations of student actions in classrooms taught by control teachers:

Asking for attention of group by raising hands
Listening to the teacher
Following teacher directions
Engaged in teacher led laboratories
Doing textbook assignments
Doing assigned worksheets
Working alone
Sitting at their desks
Taking notes on class assignments
Interacting occasionally with other students
Listening to lectures
Do not consider further applications of what they are assigned to do
Little student-student interaction
No focus on creativity

No urging to apply information in other settings
Do what the teacher and experts support
Rarely interact with other students or outside guests

Desired Emphases for Science Students

Since the development of the 1996 National Science Education Standards, the recent Next Generation Science Standards of 2013 have been released for science teaching. The Achieve (2013) team was asked to look at the "More/Less" Emphases of reform teaching but stated that nothing needed to be done since the Old Standards were fine as stated. Therefore, the 1996 NSES for science teaching continues to be used.

Many times Chautauqua teachers engage in debates concerning the different features for teaching. Chautauqua teachers are encouraged to think beyond just their classroom teaching and to share ideas concerning the "Desired Emphasis" of reform efforts with other teachers. It can be noted in the following outline the contrasts between Chautauqua teaching (Desired) and Control teaching (Typical). The aim of the Chautauqua Programs is to encourage more "Desired" teaching (see Figure 2).

Desired Teaching Traits	**Typical Teaching Traits**
Understanding and responding to individual student's interests, strengths, experiences, and needs	Treating all students alike and responding to the group as a whole
Selecting and adapting curriculum	Rigidly following curriculum
Focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes	Focusing on student acquisition of information
Guiding students in active and extended scientific inquiries	Presenting scientific knowledge through lecture, text, and demonstration
Providing opportunities for scientific discussion and debate among students	Asking for recitation of acquired knowledge
Continuously assessing student understanding (and involving students in the process)	Testing students for factual information at the end of the unit or chapter
Sharing responsibility for learning with students	Maintaining responsibility and authority
Supporting a classroom community with cooperation, shared responsibility, and respect	Supporting competition among students
Working with other teachers to enhance the school science program	Working alone in planning lessons

Figure 2. Desired and typical teaching traits. Adapted from the National Research Council, 1996, p. 52. Copyright 1996 by the National Academy Press.

Applications of Chautauqua Experiences

The most important thing is that Chautauqua teaching has led to successes with improved reform efforts for science teaching, even for teachers *without* the Chautauqua experiences. Many Control teachers at the Chautauqua Sites wanted to be involved and to observe Chautauqua teaching to improve their own teaching efforts. Even high school students were interested in the applications of science process skills in their classrooms and personal lives. The students taught by Chautauqua teachers excelled in terms of their understanding and use of the six science process skills as indicated in the two Tables and Figure 1.

Typically little attention is given in classroom settings for increasing development of more positive thinking concerning science. Students in the Chautauqua taught classrooms demonstrated their use and understanding of six process skills by doing individual or group projects, urging more questioning and looking for explanations concerning their questions, and founding ways of testing the validity of proposed ideas. Even projects involving plugged up toilets and how rockets are propelled into space are ways of demonstrating science process skills. These are things that get students interested in science processes and to encourage them to ask questions and to solve problems (why does something happen and what causes it to happen?). The Chautauqua teaching process must be implemented into classrooms for reform efforts to take place. The use of Applications indicates new measures of success with what students have learned and the need to include more school administrators, parents, school board members, community leaders, as well as business associates outside the school classrooms to implement more reform efforts. We need to encourage reforms if we are to continue improving science teaching and student learning. All students need to be encouraged to think outside the box and to get involved more in science efforts and student learning. This is what Chautauqua teaching does and will continue to do if we encourage more reform efforts to be implemented in *all* schools.

Are students disadvantaged by a Chautauqua approach? The students may not be exposed to as many topics in a course, but the chances are greater that they will learn the scientific methods of hypothesizing, collecting information, revisions in the hypotheses based on experimental data, and then reaching conclusions. Because the Chautauqua-type learner has a greater chance to be engaged in the actual discovery and learning processes, they become more excited and interested in more advanced science courses and future science careers.

Thinking, speaking, and listening are all practices of freedom for all students; not only students considered as being *advanced*. We need to be more successful in "*What*" we teach vs "*How*" we teach all students (Yager, S. & Yager, R.E., 2014). We need to encourage teachers to think about other uses and understanding of the process skills and how to encourage students to think more about how to use the skills in the *whole* community and not just in classrooms.

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