**THE WILKINS INSTITUTE FOR SCIENCE EDUCATION:
A SCIENCE-CENTERED MAGNET SCHOOL**

A dissertation submitted

by

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ABSTRACT

The Wilkins Institute for Science Education:

A Science-Centered Magnet School

by

Gary Dean Wilkins

The problem that this study addressed is that excellent science instruction is not consistently provided by traditional public schools. This study utilized a review of the literature, interviews, surveys, and focus groups. This study provides the basis for the proposed design of a school that can be the solution to the problem.

Conducted in 1995, the Third International Mathematics and Science Study (TIMSS) showed that our efforts to improve U.S. education have had some successes, but overall have been ineffective in raising U.S. performance from a middle-of-the-pack position. At the end of secondary schooling, which in the U.S. is 12th grade, U.S. performance was among the lowest in both science and math, including our most advanced students (National Center for Educational Statistics, 2001).

For this research project I surveyed 412 students and 218 parents or guardians. I conducted interviews and focus groups with 10 participants who were science teachers or educators, and 10 participants who were scientists. The surveys presented 12 factors, believed to be valued as part of an excellent science education, which were security,

social activities, sports, computers, reading and writing, hands-on equipment, industry support, and cafeteria. The survey participants rated each factor from most to least important. The focus groups and the interviews covered science education in general, as well as these same 12 topics.

Students and parents agreed that qualified instructors is the item that is most important to provide quality science instruction. Students and parents disagreed most on the item reading and writing, which students ranked 9th, but parents ranked 2nd, a difference of 7 rankings. Considering only the item that was ranked number 1, students identified sports most often as most important, but parents disagreed and ranked this 8th, a difference of 7 ranks.

After this dissertation is completed, it is my intent to benefit students with the implementation of the Wilkins Institute for Science Education (WISE), a model K-12 school dedicated to the field of science. The school will be named for my father, George Wilkins, who made outstanding contributions to the field of aircraft engineering.

Key Words: education, magnet, school, science, science-centered.

DEDICATION

This dissertation is dedicated to the memory of George Wilkins, who valued education, enjoyed science, and always had time to help others. It is intended that the WISE will be built upon the values that my father lived by.

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CHAPTER ONE: Introduction

This first chapter of the dissertation will present definitions, a statement of the problem, research objectives, praxis, and research limitations. The intent of this study is, by use of the literature, interviews, surveys, and focus groups, to establish what factors are desired in relation to providing quality science education. The results of the study will form the basis for the development of a model K-12 science-centered magnet school to be known as the Wilkins Institute for Science Education (WISE).

Definitions

In this dissertation the following terms are defined as per the National Center for Educational Statistics (2001): *Quality science education* is defined as producing students who can perform scientific research, understand the fundamental concepts of science, and are able to become successful scientists. *Excellent science education results* are defined as test scores in the top 10% on international and state standardized science assessments. *A school dedicated to the field of science* means that the school utilizes science as a central focus to provide outstanding instruction in science and math, as well as integrated instruction including English, art, music, and other subjects (National Center for Educational Statistics, 2001).

Statement of the Problem

The Third International Mathematics and Science Study (TIMSS) was conducted in 1995. The results of the study, which consisted of standardized assessments and classroom observations, were published in 2001. The TIMSS showed that our efforts to improve U.S. education in math and science have had some successes, but overall have been ineffective in raising U.S. performance from a middle-of-the-pack position. At the 4th grade, U.S. students were above the international average in both science and math. Math is relevant because of its close relationship with science, especially the physical sciences. In the 8th grade, U.S. students scored above the international average in science and below the international average in math. At the end of secondary schooling, which in the U.S. is 12th grade, U.S. performance was among the lowest in both science and math, including our most advanced students (National Center for Educational Statistics, 2001).

The TIMSS noted that 8th or 9th grade math in the U.S. is comparable to the 7th grade content of other countries. Japanese and German students, who scored highest, usually understood math concepts as well as how to solve problems, so they could also solve future problems. This was rare for U.S. students. The TIMSS noted that 11th grade science in the U.S. is equivalent to 9th grade science internationally. New U.S. math and science teachers receive less on-the-job training than Japanese and German teachers. By their final year of secondary school, 66% of U.S. students and 79% of students internationally are taking math, and 53% of U.S. students and 67% of students internationally are taking science (National Center for Educational Statistics, 2001).

The TIMSS also noted that the top 10 to 20% of U.S. students, defined as those enrolled in physics and calculus, outperformed no other countries. A gender gap favored U.S. males in physics and calculus. U.S. students spent less time on homework. More U.S. students had jobs, and they worked more hours. U.S. students watched the same amount of television as students internationally. The report found that teachers with more training in math and science than required for their teaching certificate are often more effective. Too many teachers who are teaching science are out of their fields of expertise. Too few schools have challenging math and science curriculum and texts. There is a lack of connection between the current understanding into how students learn and actual classroom practices (National Center for Educational Statistics, 2001).

The STAR SAT-9 national assessment is not even given for science until grade 9. It would be understandable if K-8 schools concentrated on subjects other than science that are assessed by the STAR SAT-9. Further, it may be that K-8 schools, which take time away from assessed subjects to provide science instruction are penalized by this test. In California, 9th, 10th, and 11th graders were each at the 45th percentile on the 2001 STAR SAT-9 science assessment. Without English learners, each of these grades was at the 50th percentile (California Department of Education, 2001). California State Superintendent of Schools Delaine Eastin said that the scores "reflect the reality that science has not been formalized into the daily lesson plan in many of our districts" (State Student Science Scores, 2001).

I have been a science teacher for a decade, a scientist for 25 years, and a science student prior to that. In my experience at public high schools, the resources and expertise allocated for science instruction have been deficient, and what have been available have been underutilized. When I taught at public elementary schools, science instruction was nearly nonexistent.

The problem that this study will address is that excellent science instruction is not consistently provided by traditional public schools. It is my intent with this study to utilize interviews, surveys, and focus groups to provide the basis for the proposed design of a school that can be the solution to this problem. I am a teacher because I want to help students to achieve their dreams. For this reason, after this dissertation is completed, it is my intent to benefit students with the implementation of the Wilkins Institute for Science Education, a science-centered magnet school.

This research project has grown from my work as a public high school science teacher. In my classroom I have implemented research projects that have achieved excellent science education results. One of these projects is an exploration of the planets that incorporates algebra instruction to compare the gravity, size, distance to the sun, and other properties of each planet to the Earth and to other planets. For a project that incorporates language instruction, students utilize current science articles to create essays that respond to questions about science. A project that incorporates art instruction is the building and painting of papier-mache models of each of the planets.

As a result of projects of these types and other instruction, in reviewing test scores for my science students for the 10 years that I have taught, I have found that more than 95% of the students in my science courses have improved their science scores on standardized tests. This research study will help to develop this successful teaching into a school that, when implemented, will provide quality science education to many students.

Research Objectives

The purpose of this study is to establish what students, parents or guardians, and experts in the community desired for science education. This provides a basis for a proposed plan for the development of the Wilkins Institute for Science Education

(WISE), a model K-12 magnet school dedicated to the field of science. Principles that were utilized in the development of the model were identified through review of the literature, surveys, interviews, and focus groups.

Praxis: Theory and Practice

It is intended that this study will lead to a proposed plan for a school for science education that is so desirable and so complete that the plan will be implemented, for it is then that the benefits to students will occur. This action research project began with a study of the subjects represented by the knowledge areas of the doctoral program at the Fielding Graduate Institute. I analyzed this against my experiences in my decade of practice as a science teacher. This resulted in the selection of a problem. I conducted a review of the literature with focus upon the problem; this led to a narrowing upon selected areas to be investigated. I used a survey, focus groups, and interviews to collect data regarding the factors. I then developed a proposed plan for a school for science education.

Research Limitations

This project is limited to science education. The focus groups and interviews are limited to individuals in a single community. The survey of parents or guardians and students is limited to a population at a single high school.

This chapter of the dissertation has looked at definitions, a statement of the problem, research objectives, praxis, and research limitations. The next chapter of the dissertation will review the literature.

CHAPTER TWO: Literature Review

This second chapter of the dissertation, the literature review, will consider systems thinking, accountability and assessment, small classes and small schools, leadership, learning environment, organizational change, and effective teaching. It will look at learner-centered classrooms and schools, learning styles and ways, action research, integrated curriculum, theories of learning, diversity, and intelligences. This project builds upon previous research by considering the literature that has already been written on education, science, and science education. There is little research available about schools dedicated to science, so this research helps to fill the gap in the literature by combining the lessons in the literature on education, science, and science education to provide a basis for a proposed design for a science-centered school.

Systems Thinking

There are a number of major characteristics common to excellent education in general, and outstanding science education in particular. One of the most obvious characteristics is the consideration of system thinking. The proposed plan for a school may utilize system thinking to consider how systems such as parents, business, and school administration influence learning in the classroom.

Asayesh (1993) stated that systems thinking involves seeing relationship between the parts to the whole within the school improvement effort. School changes do not occur in isolation. Usually, the entire system is affected by a change in one area. The organization and content of curriculum influences the instructional methods used by teachers

(Asayesh, 1993). Fullan (1995) wrote that learning is the product of education. Changes that effect learning must be implemented where learning takes place. However, site-based management movements create dependencies and diversions that defeat reform. Necessary changes require a radical re-culturing of the school, and a basic redesign of teaching (Fullan, 1995). According to Sirotnik and Clark (1988), a school-centered renewal process makes the school the target of improvement and the site of inquiry and reflective practice. Changes to any part of the school system should be considered in terms of their relationship to learning. Changes to the school system should have a positive effect on education in the classroom (Sirotnik & Clark, 1988).

Capra (1996) noted that language permits human consciousness to have the ability to abstract. Abstract thinking has led us to think of the natural environment as separate from ourselves (Capra, 1996). Capra and Steindl-Rast (1991) commented that two systems theories influence science. One is the mechanistic theory, which views living organisms as information-processing machines, very sophisticated mechanisms that deal with input-output. Another is the self-organizing theory, which sees self-organization, in other words autonomy, as the hallmark of life. Self-organization is viewed at the level of cells, family, and society (Capra & Steindl-Rast, 1991).

Sizer (1996) wrote that essential schools utilize systems thinking to implement commonsense reform; for reform to count, the school must be addressed as a whole. Reform should create significant, reasonable change throughout the entire essential school, and relations in the hierarchy must be fundamentally rethought (Sizer, 1996). Crossman, Lane, and White (1999) stated that organizational learning is the process used to reform schools. Organizational learning has a framework of four processes: intuiting, interpreting, integrating, and institutionalizing (Crossman et al., 1999). Successful school improvement, according to Scribner, Cockrell, Cockrell, and Valentine (1999), is dependent upon four factors: principal leadership, organizational history, organizational priorities, and organization of teacher work. Changes with regard to school leadership, teachers, structures, and relationships should be focused upon their effect on the classroom. All reforms in a school system should require justification on the basis of their positive effect on classroom learning (Scribner et al., 1999).

Public confidence in the schools and educators, according to Peck and Carr (1997), can be restored through systems thinking. This process empowers all stakeholders to create appropriate learning systems. Educational institutes are heavily criticized by today's society (Peck & Carr, 1997).

According to Richmond (1993), effective transfer of systems thinking skills can be created through developing a learner-directed educational process and a systems thinking paradigm. Learner-directed education puts the focus onto the learner as the most important individual in the educational system (Richmond, 1993).

According to Bowler (1997), economic policies in the 1990s have narrowed the focus to learners, discarding community need. Systems thinking is supposed to shift the primary focus onto the individual student. However, that focus is not supposed to exclude the environment in which the individual functions. Students will not be prepared to effectively act in society if that society and its needs are not considered as part of the educational system (Bowler, 1997). Outcomes of interventions, stated Argyris (1993), conceived at the systemic level, should include a stopping of button-pushing and explosive relationships, overcoming resentment and building trust, and getting feedback from below (Argyris, 1993).

The literature on systems thinking implies that improvements need to view the whole school when making changes to parts. It means that schools, as well as cells and societies, may be viewed as self-organizing. It implies that reform needs to create significant change that affects the entire school.

This section has looked at how systems such as parents, business, and school administration, influence learning in the classroom. The next section will consider assessment and accountability.

Accountability and Assessment

In addition to systems thinking, another characteristic of excellent education in general, and outstanding science education in particular is the consideration of assessment and accountability. The proposed design for a school could consider how exhibitions, portfolios, and standardized tests relate to the needs to provide financial accountability, an accurate measure of student capabilities, and informed parental support.

Olson (2001) found that some states are increasing accountability by tying funding to performance. Standards are established, and children are tested each year in grades 3 through 8. At the federal level, President George W. Bush has established a plan for education that he calls "No Child Left Behind." In this plan he called for tests for proficiency in reading and math. His plan offered financial incentives for partnerships between colleges and K-12 schools (Olson, 2001). Exhibitions, wrote McDonald (1993), are an invention of the Coalition of Essential Schools. They are based upon the principle that graduation from high school should be based upon genuine achievement. Exhibitions measure understanding and performance (McDonald, 1993). Ascher, Ikeda, and Fruchter (1998) stated that only validated instructional programs should be implemented. Results of systematic assessments of student achievement should be published. Teachers should show evidence of learning achievement in their classroom. In the “Schools Under Registration Review Process” in New York State, schools that are low performing after 3 years are closed or redesigned. Problem areas addressed include performance, diversity, intervention, and capacity (Ascher et al., 1998).

In standards-based accountability programs, commented Haertel (2002), test scores are interpreted with reference to the ranges they fall within, categories like “proficient” or “below basic.” The validity of such interpretations requires the participation of stakeholders in establishing the criterion scores and in setting the standards (Haertel, 2002).

Tobin, Kahle, and Fraser (1990) stated that higher level cognitive learning is not achieved in traditional science classes because of curriculum that includes too much content for each topic. Laboratory activities are largely unchallenging cookbook activities. Higher level cognitive learning is prevented by science assessment tests that emphasize recall facts (Tobin, Kahle, & Fraser, 1990).

According to Schlechty and Cole (1992), seldom do those interested in assessment ask, “What capacities must schools and communities possess?” They seldom ask how these capacities might be evaluated. Assessing systems and organizations are generally overlooked (Schlechty & Cole, 1992). Fiske (1997) wrote that education should not exclusively focus on creating but should also include history, criticism, and aesthetics. The value of an education is not fully represented by products, but is also reflected in students' experiences throughout the educational system (Fiske, 1997). Portfolios, stated Niguidula (1993), give a more accurate idea of students' capabilities. Schools should use digital portfolios to account for students' abilities that may not be objectively measured, and capabilities that may not be effectively represented by letter grades or scores (Niguidula, 1993).

For about 75 years now, according to Joyce (1999), research has indicated that educators could be doing much better in the teaching of reading and writing. About one-third of students do not learn to read competently (Joyce, 1999). Berliner (1996) wrote that the standards by which literacy is judged have gone up. It gives the impression that schools are doing worse when they are, in fact, doing well. Politicians and industrial leaders have used these standards to undermine public education (Berliner, 1996). Wiggins and McTighe (1998) stated that standards should be created using backward design. Performance standards could be created by starting with what teachers want students to be able to do, the next step would be to determine how students would learn it, and then, as the final step, performance standards could be set. Performance is the key to assessing understanding. High standards will not cause excellent student performance (Wiggins & McTighe, 1998).

Giroux (1999b) commented that the emphasis upon accountability is growing. The parties who are currently influencing the creation of assessment tools, however, are not those who are making positive contributions to excellent education (Giroux, 1999b). When people talk about accountability, according to Sizer (1996), the assumption is, if schools were really held accountable, they would clean up their act. Most involved in the debate over education agree that the local and state boards of education and the administrators that work for them do not do that function well. The scores from high stakes tests will be made public, in the hope that humiliation will provide remedial action (Sizer, 1996).

Kohn (2000) stated that the current use of standardized tests in education is unparalleled. Most experts condemn the use of high-stakes testing for children less than 9 years of age. Experts condemn making important decisions, such as graduation and promotion, based upon a single test. The time, money, and energy that are used for standardized tests could be utilized to improve the quality of instruction. Non-instructional factors explain most test score variance. Standardized tests measure superficial thinking (Kohn, 2000).

The literature on accountability and assessment implies that school funding is becoming increasingly dependent upon performance. It means that stakeholders should be participating in establishing the criteria for the standards to which schools are held accountable. It implies that high-level cognitive learning is prevented by assessment tests that stress recall.

This section has looked at how exhibitions, portfolios, and standardized tests relate to the needs to provide financial accountability, an accurate measure of student capabilities, and informed parental support. The next section will consider small classes and small schools.

Small Classes and Small Schools

In addition to assessment and accountability, another characteristic of excellent education in general, and outstanding science education in particular is the consideration of small classes and small schools. The proposed concept for a new school may look at how school size and classroom size effect teacher control, effective reform, and student achievement.

Sizer (1996) wrote that the actual load of teachers in typical Los Angeles area high schools is 192 (instead of 130 or fewer in well-respected schools). The "world-class standards," so easily set, are utterly unattainable in such schools. Gestures from the top are seen by embittered veterans as a sop meant to distract the public at large from facing the fact that schools as currently structured cannot meet the standards we should expect. In all, there is an epidemic of cynicism and a sense of betrayal, especially among the ablest school people (Sizer, 1996).

Wasley (2002) commented that following the attacks of September 11, 2001, educators have a renewed appreciation for the importance of the basic freedoms we enjoy and the advantages that a democracy provides to its citizens. Half a century ago, proponents of the school consolidation movement suggested larger schools would provide opportunities to track students. Today, less-advantaged students end up in the largest classes, with the least-experienced teachers, with the least-engaging curriculum, and with the least-effective instructional strategies. When class size is smaller, teachers are able to engage students in meaningful discussions of issues, and they are able to help the children to build critical citizenship skills (Wasley, 2002).

Klonsky and Ford (1994) wrote that school reform and improvement activities are more likely to be productive in small schools. Small schools are less likely to produce adversarial school policies, and more likely to encourage strong democracy (Klonsky & Ford, 1994). Klonsky and Klonsky (1999) stated that small schools alter the relationships within the school, lead to teacher collaboration and student visibility, and establish true learning communities (Klonsky & Klonsky, 1999). Educational technology, according to Rockman (1987), encourages decentralized decision making and increased teacher control. Schools should have a maximum of 250 students and 10 teachers, which would enable productive reform activities and student visibility (Rockman, 1987).

In large schools, wrote Sizer (1996), the activity of the principal is crisis management, not changing, not rethinking, not reforming, but going.

> Among teachers exists a conspiracy, no one would tell the truth when it could remain unspoken, no one would dare ask about implications for tomorrow. Appearance and meeting the expected requirements is all. Technology is used to track students with no action implied, data for data's sake. Time for teachers to meet during the day? None to speak of. Why is all the reformist rhetoric followed with nothing but trivial action? What we do not see is any change in school routines – the rushed schedule, the division of subject matter, the emphasis on coverage, the arranged anonymity. (Sizer, 1996, p.6)

According to Stasz and Stecher (2000), you can ask any teacher, and they will tell you that the priority to achieve quality education is smaller class sizes. Any expenditures that are made for texts, facilities, materials, training, or resources should not be made prior to using available funding to provide qualified teachers for small-sized classes. California has provided incentives for class-size reduction in grades kindergarten through 3. Qualifying classes have a maximum of 20 students. Smaller class sizes allow teachers to spend more individual time with students. Class-size reductions have improved student achievement, and have increased positive teacher attitudes (Stasz & Stecher, 2000).

Bigness, according to Sizer (1996), signals a need for order: standardized routines and a rule-driven, impersonal culture. Large schools should be broken into smaller units; this can occur at a shared large facility. Interdisciplinary work can be done within the small units: These are not factories. Collective work brings respect and common focus that energizes a faculty. Visitors perceive these to be safe places, that the faculties are pulling together and sharing pride in their work (Sizer, 1996).

The literature on small schools and small classes implies that outstanding performance is unattainable at large schools. It means that small schools provide the opportunity to discuss subjects meaningfully and to develop citizenship skills. It implies that reform and school improvement efforts are most effective when implemented at small schools and small classes.

This section has looked at how small classes and small schools affect teacher control, effective reform, and student achievement. The next section will consider leadership.

Leadership

In addition to small classes and small schools, another characteristic of excellent education in general, and outstanding science education in particular is the consideration of leadership. The relationship between leadership that is committed to instruction, that supports teachers' growth, that is creative, and how that leadership could influence student achievement, may be considered in the proposed design for a school.

According to Hart and Willower (1994), the robustness of the school environment is positively linked to the commitment of the principal. The measure that matters is the teachers' perceptions of their principals' commitment (Hart & Willower, 1994). Leithwood, Leonard, and Sharratt (1998) stated that the condition that fosters organizational learning is the transformational form of principal leadership. Schools need leadership committed to instruction to achieve a robust environment for organizational learning (Leithwood et al., 1998).

DuFour (2002) posited that the principal must serve as the learning leader, not the instructional leader, of the school. The leader's efforts must be driven by the questions; to what extent are students learning the intended outcomes, and what can the leaders do to give students and teachers the time and support to improve learning? The learning leader shifts to focus from inputs and intentions, to outcomes and results (DuFour, 2002).

According to Morgan (1996), principals need skills in reading the situations they organize or manage. Although management based upon images and metaphors can lead to partial understanding, illustrative themes that principals should understand are the school as a mechanism, as an organism, as a brain, as a culture, as political, as a psychic prison, or other images (Morgan, 1996).

Artistic principals, stated Bolman and Deal (1991), use reframing to lead schools. Through reframing, they use multiple lenses for organizational analysis. These lenses view the structure, human recourses, politics, and symbolism. Reframing leads to managerial freedom and leadership effectiveness (Bolman & Deal, 1991). Morgan (1997) wrote that creative principals manage change in decentralized organizations. Schools self-organize in open yet controlled ways. New images clarify and consolidate organizations (Morgan, 1997).

Senge (1996) noted that there is a difference between commitment and compliance. When employees, such as teachers, comply with the decisions of a leader, such as a principal, a business or school can function, make superficial changes, and slowly, silently spiral downward. But when teachers are committed, significant change and growth can be created. Teacher compliance is attained when principals tell teachers what to do; however, teacher commitment comes from teachers being supported by management (Senge, 1996). According to Riehl and Sipple (1996), in a safe environment as created by a supportive principal, committed teachers experiment with new methodologies to see if they lead to improved learning, and networking committed teachers carry the seeds of growth from the successful experiments to other classrooms. Sustained growth requires the continued operation of teachers in the roles of line-leaders and networkers. Teacher turnover disrupts or ends school change and growth. Turnover is minimized by increasing teacher influence, autonomy, and collegiality (Riehl & Sipple, 1996).

According to Timar (1997), reform has lacked control by the schools, to shape policy, consider interests, and control conflict. Since the early 1980s, there has been more accountability to state education departments, which have been controlled by special interests (Timar, 1997).

Efforts by school leadership to recruit good new teachers, wrote Olson (2000), include tax breaks, scholarships, and loans. Some of these incentives require the teacher to serve in a high need area (Olson, 2000).

Pounder, Ogawa, and Adams (1995) wrote that teacher leadership does not need to be an issue of individual empowerment. It should be approached as an issue of organizational development. Effective schools are led by committed principals, and by groups of committed teachers. Also, the leadership of parents is positively associated with student achievement (Pounder et al., 1995). Smylie and Denny (1990) stated that the development and performance of leadership roles are mediated by the organizational context. Teachers should be involved in all aspects of management of schools. As well, students and their parents should be expected to participate in guiding schools toward providing excellent science education (Smylie & Denny, 1990).

Are schools, asked Cooper (1996), run by those who control those hired to manage them: superintendents, school principals, and district office policymakers? Or are they really run by those who control the teaching-learning process: teachers, department chairs, and curriculum specialists? Many teachers would rather have administrators meeting with each other rather than bothering teachers and students (Cooper, 1996).

From Attila the Hun to the present, according to Bolman and Deal (1994), leadership has been needed to foster purpose, passion, and imagination. We look to leaders for hope, inspiration, and a pathway to somewhere more desirable (Bolman & Deal, 1994). Beck and Murphy (1992) wrote that the work of principals as school leaders could be theoretical, conceptual, empirical, and prescriptive. Principals especially need to be effective leaders because of the central role of symbols and culture in schools (Beck & Murphy, 1992).

The literature on leadership implies that committed leaders are necessary to achieve organizational learning and to improve student achievement. It means that learning leaders are needed to attain outcomes and results. It implies that artistic principals achieve freedom and efficiency by using reframing to view organizational structures and human relations.

This section has looked at how leadership that is committed to instruction, that supports teachers' growth, that is creative, could influence student achievement. The next section will consider the learning environment.

Learning Environment

In addition to leadership, another characteristic of excellent education in general, and outstanding science education in particular is consideration of the learning environment. A proposed design for a school could address how the educational environment affects the personal, diverse, and changing needs of the student.

Nearly all educators, according to Gardner (1993), acknowledge the failure of the factory model of education. Among educators there is a surprising degree of consensus that schools' difficulties arise from a variety of sources--broken homes, lessening of respect for authority, time spent watching television--and that these cannot be alleviated by a "quick fix." Many American students are faced with crumbling facilities and drug and crime-infested neighborhoods reminiscent of Dickensian London. Opinion leaders propose "sound bite" solutions, a rhetoric of culprits and quick cures. The most appropriate model for talking about school change is the idea of building a new community (Gardner, 1993).

According to Gilmore and Murphy (1991), each student attributes unique meaning to his or her classroom environment. Students use highly individualistic concepts, which are mediated through relationships among students (Gilmore & Murphy, 1991). Astley (1985) stated that in making sense of an organization, a homogenous conception of the classroom environment would be flawed. Student populations undergo evolutionary changes as well; the populations themselves rise and fall (Astley, 1985).

Field theory, wrote Schwartz (1993), asserts that predispositions, acquired characteristics, uniqueness, and behaviors of an individual impact and are affected by events and people in the environment. In any classroom there are students who vary greatly, one to the next. Effective teachers recognize these differences, and provide multiple instructional methods to match individual learning styles. Just as teachers must adapt to individual needs, schools must adapt to the varied environments that affect their outcomes (Schwartz, 1993).

According to Maruyama (1992), field theory has led educators to focus on the individual within a social setting, on the social forces that influence individuals, on the freedom given to students to explore their environment, and on the structure of the environment. Sharing the responsibility for education with the individual student requires that a degree of control needs to be turned over to the individuals. Student freedom comes with significant risks. Undoubtedly some students do not make responsible choices. If society is unwilling to accept these setbacks, then field theory cannot be sustained in the educational setting (Maruyama, 1992).

Edelman (1992) stated that schools should teach lessons like working for everything that you get, setting goals, individual initiative, substance over style, perseverance, and making a difference. Children need a seamless web of family, community, and government support (Edelman, 1992). Maeroff (1998) wrote that schools should build links to the community. Children need to have a sense of belonging to thrive in school (Maeroff, 1998).

Kaplan and Owings (2000) stated that without safety, there is no learning. Schools should have high expectations for the achievement and behavior of students. Small is better; class-sizes should not exceed 20, and schools should not have more than 200 students. Teachers know that learning is built upon discipline. The best lessons are ineffective unless classroom discipline is established prior to instruction (Kaplan & Owings, 2000).

An environment that provides opportunity to learn, according to Kilgore and Pendleton (1993), has two major dimensions: the amount of exposure and the quality of exposure. The amount of exposure includes enrollment, rate, and length of exposure to learning. The quality of exposure to learning includes intensity and accessibility (Kilgore & Pendleton, 1993). Astuto and Clark (1995) stated that organizational resources effect the acquisition of knowledge by setting constraints. Schools provide other impediments to learning: mediocrity and instrumentality, competition and standards, repressive policy directions, and bureaucracy (Astuto & Clark, 1995).

Giroux (1999a) wrote that public education has a role in keeping democracy alive. Privatization undermines this role. The encroachment of corporatism into school environments offers consumerism in place of citizenship (Giroux, 1999a). Giroux (1999b) also wrote that corporations are dominating public education. School leaders are changing into the roles of corporate managers. Higher education is becoming increasingly vocational (Giroux, 1999b).

Singh and Oztrk (2001) found that part-time work has a significantly negative effect on students' academic performance. Employment disengages students from the school environment. Financial need is not the only reason students work; in families with higher incomes there is a greater probability that the adolescents will work. Consumerism is the motivator. The adolescents spend the money on items they do not need (Singh & Oztrk, 2001).

Cook, Murphy, and Hunt (2000) wrote that the Comer School Development Program initially improves the social environment of the schools. There is a reduction in acting out. Later, academic gains are made in Comer schools, such as a 3-percentile points year-to-year improvement in mathematics. Some successful Comer methods include allowing students to consider other students' behaviors and to determine consequences, discussing social issues with students, recognizing and valuing cultures, teaching through divergent modalities such as music and art, utilizing parents as committed participants in instruction, and others. Comer schools are especially appropriate when the community norms for behavior include violence, conflict, disruption, and other conduct that prevents learning. When acting out is reduced, then academic instruction is increased, and learning performance is improved (Cook et al., 2000).

Edelman (1994) commented that gun violence at schools is robbing thousands of children of their lives, and countless others of a healthy and secure childhood. Only when our children feel secure will they be ready to learn (Edelman, 1994).

The literature on learning environment implies that difficulties at schools can be attributed to troubles in society. It means that multiple instructional methods should be used to match unique and changing students' needs. It implies that field theory requires teachers to take the risk of turning over more control to students.

This section has looked at how the educational environment affects the personal, diverse, and changing needs of the student. The next section will consider organizational change.

Organizational Change

In addition to the learning environment, another characteristic of excellent education in general, and outstanding science education in particular is the consideration of organizational change. The proposed concept for a school may look at how teachers' attitudes, shared decisions, and recognition relate to organizational change.

School leaders, according to Peterson and Deal (1998), are the key to building positive culture, and to eliminating toxic culture. Culture influences how staff dress, what they talk about, their willingness to change, instruction, and learning. In a toxic culture, teachers are ready to attack new cultures. They make fun of those who volunteer to go to workshops. Their meetings are battlegrounds (Peterson & Deal, 1998). Deal (1991) wrote that schools create meaning by attending to cultural attributes. One school hosted a formal dinner to celebrate their teachers (Deal, 1991). Fullan (1998) stated that principals gain insight by respecting those that they want to silence. They should manage rationally and emotionally, and they should fight for lost causes (Fullan, 1998). Fullan (1992) also stated that principals would do more if they built upon collaborative cultures, rather than charging forcefully in with heavy agendas for change. Teachers should be encouraged to try pilot programs, based upon research of how learning best occurs, that can lead to school-wide implementation of successes, or the gain of knowledge from failures (Fullan, 1992).

Smith (1998) wrote that teachers begin to influence school-wide change by experiencing effective learning. Others need that experience, so teachers can invite administrators and parents to participate in classical learning in their liberated classrooms (Smith, 1998).

Teachers' responses to reform, according to Wolf, Borko, Elliott, and McIver (2000) are connected to their positive stance toward learning and the principal's leadership. Teachers' willingness to accept change is connected to social factors, trust, and willingness to risk. Positive teachers, when convinced that a change creates progress toward quality education, will accept the additional effort and stress associated with doing things in new ways. Principals can create an environment in which change is successful. They can develop collegiality among teachers, develop trust by having their actions validate their words, and provide positive consequences for failures (Wolf et al., 2000).

Cibulka (1997) wrote that schools are experiencing a crisis in legitimacy. Public opinion favors a major overhaul, if not a dismantling of the present education system (Cibulka, 1997). Sarason (1998) wrote that the model for school improvement is found in business. Educational improvement efforts are doomed as long as schools are viewed as unique organizations. Coordination and collegiality is key to all (Sarason, 1998).

Glaser, Lieberman, and Anderson (1997) wrote that the American Educational Research Association (AERA) has identified the need for the reflective practitioner. Reflective practice occurs when an organization develops that allows for practice and research to occur in unison (Glaser et al., 1997). Discoveries in biology, physics, and chemistry, stated Wheatley (1994), lead to new views of organizational change. The world is cooperative and system seeking. Relationships are required for existence. Life is a great experimentation (Wheatley, 1994). According to King (1993), collaborative inquiry builds schools' capacities for change. Collaborative inquiry utilizes dialog between principals, teachers, and researchers (King, 1993).

Inequitable distribution of resources, stated Ayers (1994), leaves city schools starved and desperate. Bureaucracies leave large schools lifeless, hopeless, and gutless (Ayers, 1994). School improvement, wrote Joyce (1990), usually is intended to change the technical, political, or the structural environment. Technical changes involve curriculum and instruction. Political/social changes modify relationships within the school. Civic priorities must also be affirmed. There is widespread concern that education for citizens has been neglected (Joyce, 1990). According to Ayers and Klonsky (1994), to save city schools, it will take the capacity to imagine a different world, the courage to sustain that vision, and the work to make it real. Skepticism is understandable; if contemporary schools are good, then the world should be getting better (Ayers & Klonsky, 1994).

Sizer (1996) wrote that the traditional American organization of schools was designed in 1895. Schools have rewarded students for merely showing up and passing through; students have little idea what serious intellectual work involves. All the public controversy itself is a cause for hope; the invective has legitimized a searching rethinking of what schooling is about. There is an explosion of energy in parents and local citizens in support of essential schools. From graduations where the atmosphere is electric, many students at essential schools who never dreamed of going to college are going on to college (Sizer, 1996).

Schein (1996) wrote that inattention to social systems in an organization leads to underestimating the importance of culture-shaped norms, values, and assumptions. Organizational learning fails due to cultural responses (Schein, 1996). According to Newmann, Rutter, and Smith (1989), each school has a unique and specific culture. Without knowledge of the specific conditions of the culture, and consideration for those conditions, implementation of change is doomed to disappointment and failure. The most powerful organizational effects to reduce the alienation of teachers are teachers helping one another, responsive administrators, students' orderly behavior, teachers' knowledge of one another's courses, and the encouragement of teachers' innovation (Newmann et al., 1989).

Smart and St. John (1996) stated that school organizations that have an identifiable culture type are more effective. A strong culture type relates to strong performance (Smart & St. John, 1996). According to Cheng (1991), a strong culture type can be conceived of as a family. The family utilizes commitment. Another strong cultural environment can be thought of as a clan. The clan emphasizes control. Other typical cultural styles of organizations are disengagement and headless. These culture types are weak. Schools that have disengaged or headless cultural environments are poor performing (Cheng, 1991).

The literature on organizational change implies that toxic culture can be overcome by building upon a positive culture and by fighting for worthwhile causes. It means that positive teachers are the key to reform that achieves quality education. It implies that there is a need for reflective practice and for collective inquiry.

This section has looked at how teachers' attitudes, shared decisions, and recognition relate to organizational change. The next section will consider effective teaching.

Effective Teaching

In addition to organizational change, another characteristic of excellent education in general, and outstanding science education in particular is the consideration of effective teaching. The proposed plan for a school could address how teachers working together, observing the work of others, and teachers' belief systems relate to effective teaching.

Kyle (1997) wrote that some things are best learned from study and practice, such as math or physics. Other efforts require a knack, a mastery of the skills as they are used in real settings; these efforts include woodcarving or performing surgery. Teaching requires study to acquire the basic knowledge upon which a teacher's actions in the classroom transform into knack, a mastery of the use of teaching skills in academic situations that usually comes from experience (Kyle, 1997).

According to Noffke and Stevenson (1995), it is a widely held belief that learning to teach takes time. Collaboration can reduce that time. Acquiring the knack of teaching is accelerated when a teacher has the opportunity to observe and receive mentoring from a more experienced teacher (Noffke & Stevenson, 1995). Through collaboration, wrote Clift, Veal, Johnson, and Holland (1990), new teachers can reflect on how the strengths of other teachers' practices can be incorporated into their own works. Mentoring naturally occurs when experienced teachers view new teachers' works. The five dimensions of learning which collaboration develops are leadership, structures, individuals, relationships, and synergy (Clift et al., 1990).

Taylor (1987) stated that the art of presenting a science lesson is a dramatic one. The most readily available technology for transferring science information from teachers to students is that of the theatre (Taylor, 1987).

Effective teaching, stated Starnes (2000), is based upon the personal values and the belief systems of teachers. They are required to hurry past the program, workbooks, scripts, and observations, to teach (Starnes, 2000).

Tobin, Kahle, and Fraser (1990) wrote that for the training of science teachers, knowledge of the subject content and how to teach the content are both extremely important. Only sustained observations clarify science teacher effectiveness (Tobin, Kahle, & Fraser, 1990).

According to Kidder and Born (1999), students should be taught dilemma patterns such as individual versus community, truth versus loyalty, and justice versus mercy. Shared values that should be taught include compassion, honesty, fairness, responsibility, and respect (Kidder & Born, 1999).

The reality of teaching today, stated Burley, Yearwood, Elwood-Salinas, Martin, and Allen (2001), can be seen in the advice that veteran teachers may offer to new teachers, that commonly includes: Never turn your back, don't let them see you smile, and make sure you cover all of the material. This is the reality that has existed as teachers have tried to survive in the present schools; adversarial relationships exist all around (Burley et al., 2001).

Hendry and King (1994) found that the transmission of knowledge approach to teaching science can lead to students learning in a dysfunctional way. The teacher must ascertain what ideas are evoked by contexts so that the knowledge acquired will be useful (Hendry & King, 1994).

Key ideas, stated Sizer (1996), must be visited and revisited, in ever more demanding forms. Advanced work should be more complex, abstract, or difficult; it is not simply more elementary work. Just as a virtuoso gives life to a piece, students can deeply understand other subjects, grasping a meaning beyond mere composition (Sizer, 1996).

According to Feldman (1996), teachers generate and share knowledge and understanding by anecdote telling, trying out new ideas, and systematic inquiry. Their knowledge and understanding grows by being-in-the-world and through enhanced normal practice (Feldman, 1996).

According to Siegal and Barr (1997), ethical issues, which affect the conduct of teaching, have been shaped by societal events. The Nuremberg trials, which recounted the "medical experiments" of the Nazis on concentration camp inmates, and the Manhattan Project, which led to the dropping of the atomic bombs on Japan in 1945, have dispelled forever the notion of science as neutral (Siegal & Barr, 1997).

Globalization, stated Dale (2000), causing society to progress toward cultural homogeneity, becomes a consideration for teaching. In the end, globalization may make states and nations obsolete. Globalization is driven forward by the irresistible growth of information technology (Dale, 2000).

Griffen (2000) wrote that schools, as well as news and advertising, attempt to insure group conformity by idealizing the "American Way of Life." Schools transmit the market/capitalist system goal; "what is," the requirement to sustain growth and development. Conservationists would like schools to teach; "what should be," a consideration of environmental needs (Griffen, 2000).

Bidwell, Frank, and Quiroz (1997) stated that it is likely that students will always be required to learn effectively from varied instructional approaches. Teacher types, each comprising distinctive attitudes toward work, are the link between control systems and behavior (Bidwell et al., 1997). Elmore, Peterson, and McCarthey (1996) wrote that the relationship between formal organizational structure and teaching practice is weak and indirect school structure is not likely to be successful in unifying classroom instruction. Schools benefit from the shared information between teachers that leads to the spread of effective lessons and practices (Elmore et al., 1996).

The literature on effective teaching implies that a teacher's experience should include study, practice, and experience, to develop skills and a knack. It means that collaboration, observation, and mentoring are effective means to prepare teachers for excellence. It implies that teachers are effective, despite programs, workbooks, and other obstacles, because of their personal values.

This section has looked at how teachers working together, observing the work of others, and teachers' belief systems relate to effective teaching. The next section will consider learner-centered classrooms and schools.

Learner-Centered Classrooms and Schools

In addition to effective teaching, another characteristic of excellent education in general, and outstanding science education in particular is the consideration of learner-centered classrooms and schools. Student preferences, ownership of learning, and choices, in relation to learner-centered classrooms and schools, may be addressed by a proposed plan for a school.

According to McCombs and Whisler (1997), consensus is emerging that schools are living systems in service to students. Learner-centered schools provide the most supportive learning environment for diverse students. The learner-centered perspective focuses on individual learners--their heredity, experiences, and perspectives--with a focus on learning: how learning occurs, effective teaching practices, motivation, and achievement. Learning is a natural process of pursuing personally meaningful goals. Learning is influenced by personal values, expectations, and emotions. Individuals are naturally curious, and they enjoy learning. Learning and self-esteem are heightened in respectful and caring relationships (McCombs & Whisler, 1997).

Learner-centered schools, stated McCombs and Whisler (1997), are recognized by their spirit of quality and caring.

> Teachers and students express their unique talents and pursue personally meaningful goals. There are projects, debates, and community learning experiences to help students understand moral, social, or political issues. Schools address teachers' needs for collaboration and personal inquiry. Teachers inquire about the effectiveness of their practices. Schools offer mental health and counseling services. There are school-wide activities. Schools have flexible roles and responsibilities for teachers. A critical "intimacy" fosters more intense and enduring relationships. Teachers have the time and space to provide attention, respect and caring to their students. Teachers are free to share basic beliefs and values, and to struggle with bringing them into agreement with the school mission. Students have a voice in school decisions, they make choices about programs, practices, and structures, and they feel ownership of the school. Teachers and parents feel welcomed and supported in an environment in which personal and interpersonal concerns take precedence. (McCombs & Whisler, 1997, p.104)

In learner-centered classrooms, wrote McCombs and Whisler (1997), students choose their own projects, work at their own pace, and they show excitement. The teacher has high expectations, listens to and respects each student, and shares decision-making. The curriculum stimulates students' varied interests, is meaningful to students, and has opportunities for higher-ordered thinking. Learners seek to create meaningful representations of knowledge. All students are given equal attention and opportunity to respond. Teachers relate to students as human beings, and they believe in students' potential regardless of their history (McCombs & Whisler, 1997).

According to Duschl (1990), conceptual change learning as it occurs within individuals is guided by the same basic sets of principles that guide the growth of knowledge in science. A new idea is demonstrated in new situations to establish why it is a stronger explanation or concept (Duschl, 1990). Smith (1998) stated that the official theory of learning is that learning is work. Special interest groups outside of schools propagate this belief. The classical view of learning is that we learn effortlessly every moment of our waking lives. We learn without noticeable effort. This belief works with the natural strengths of the brain (Smith, 1998). Kolstoe (2000) noted that knowledge of the social aspects of science is important and relevant for science education for citizenship. Students should be engaged in thoughtful decision-making on controversial socio-scientific issues (Kolstoe, 2000).

When people remember positive learning experiences, wrote McCombs and Whisler (1997), they recall being able to pursue things they were interested in, and being given reasons for why they were being asked to learn something. Life learning experiences offer an opportunity to follow natural curiosity, lots of natural choices, time to excel, and the support of friends and family. In addition to a focus on learning, there needs to be an equal focus on the learner. When power and control is shared with students, they are more willing to learn and to be involved in their own learning. Intrinsic motivation and self-regulation are only possible in contexts that provide for choice and control (McCombs & Whisler, 1997).

In learner-centered schools, noted McCombs and Whisler (1997), there are diverse learning opportunities, exhibitions, and high expectations. Students learn that the exploration of ideas can be difficult, but also exciting and fun. Action images help students to visualize what they need to do, and skills to engage in the actions are developed. There is collaboration among teachers, and also among students. The emphasis is upon critical thinking skills and active learning. There is a focus upon developing caring and competent people. Students are active learners and reflective practitioners who apply the research knowledge (McCombs & Whisler, 1997).

According to McCombs and Whisler (1997), learner-centered classrooms have a warm, supportive environment. Students do only useful work. Engagement is supported by the relevance of school. Students are actively involved in their learning, and they develop productive habits of mind such as self-regulation and creative thinking. Teachers believe in, respect, and relate to their students (McCombs & Whisler, 1997).

Flowerday and Schraw (2000) wrote that some teachers believe that student choice in instruction promotes learning and behavior. Teachers commonly agree that individual students have preferred modes of learning that are not the same as other students (Flowerday & Schraw, 2000).

In a student-centered school, wrote Crow, Chow, Demoulin, and Reiger (2001), involvement is integral. In traditional schools, too few students are involved in extra-curricular activities; a few talented or gifted students monopolize the available resources. The honesty and fair play learned in extra-curricular activities helps to develop model students, and helps to prevent delinquency (Crow et al., 2001).

Hannafin (1997) wrote that the goals of technology-enhanced, student-centered learning environments are to encourage manipulation rather than simple acquisition, and to root the learning process in concrete experience and extended investigation. Student-centered learning environments create motivation for the acquisition of knowledge by providing meaning; later, the learning is enriched as the student acts upon what he or she has learned. Students can select aspects of the knowledge that interest them to investigate within the technology-enriched environment (Hannafin, 1997).

The literature on learner-centered classrooms and schools implies that education should focus upon the learning, motivations, and achievements of individuals. It means that students should pursue personally meaningful goals in an environment that attends to caring and quality. It implies that we learn effortlessly at all times, that if education is work it is not learning.

This section has looked at student preferences, ownership of learning, and choices, in relation to learner-centered classrooms and schools. The next section will consider styles and ways of learning.

Styles and Ways of Learning

In addition to learner-centered classrooms and schools, another characteristic of excellent education in general, and outstanding science education in particular is the consideration of styles and ways of learning. The proposed design for a school may look at how teachers' and students' preferred approaches, implementing and managing change, and mastery level accomplishment relate to learning styles and ways.

According to Gregorc and Butler (1984), individuals have an approach to learning that is most comfortable for them. Four channels of learning are concrete, abstract, sequential, and random (Gregorc & Butler, 1984). Active learning, wrote Caine and Caine (1997a), consolidates and internalizes information. Learning becomes personally meaningful and conceptually coherent (Caine & Caine, 1997a). Rico (1985) stated that students need to make patterns out of their experience. Clustering is a non-linear brainstorming technique, which helps students to make patterns (Rico, 1985).

Martin (1994) stated that hands-on, minds-on laboratory lessons make the difference for effective science teaching. Students should be analyzing, synthesizing, evaluating, exploring, investigating, and discovering science hands-on. Eighty percent of all science classes use text as the basis for instruction. When a text is used, knowing science is a function of reading and recalling information, digesting, and regurgitating (Martin, 1994).

Finn (2002) posited that most teachers find inquiry science to be a difficult experience. Being a facilitator instead of the person with all of the answers requires extra work and flexibility on the part of the teacher. Because the inquiry science curriculums emphasize collaborative, small group work, students are often not in the same place at the same time (Finn, 2002).

Li (1999) commented that the purpose of and the ethics in science should be considered in science education. Science as practiced should embody the ideal of understanding the order underlying nature. Science should be the disinterested, objective, and cooperative search for the truth (Li, 1999).

According to Olson (1982), the cooperative inquiry approach, an effective approach to science teaching, runs counter to customary science classroom practice. The cooperative inquiry approach builds a partnership between the pupil and the teacher around investigations dealing with experiential data and social issues (Olson, 1982).

Challenge Education (CE), stated Whitfield (1995), teaches students to learn and accomplish as much as they can master. CE support systems include student advisory committees, school and community agencies interface, and the self-education network (Whitfield, 1995).

In deliberate practice, noted Bransford, Brown, and Cocking (2000), a student works under a tutor to rehearse appropriate practices that enhance performance. Deliberate practice and having a coach who provides feedback for ways of optimizing performance promotes the sort of problem-solving behavior observed in scientists (Bransford et al 2000).

Chen and Armstrong (2002) posited that although it is still in its early stages, the Internet is showing us ways of connecting students and teachers to new sources of knowledge and expertise, such as the impressive collections and curators in our best museums or the creative scientists in our research centers. Such experiences offer the opportunity to break down the traditional isolation of the classroom (Chen & Armstrong, 2002).

Jensen (2000) stated that moving, stretching, and walking enhance the learning process. Schools that wish to improve students' percentile scores on standardized tests, instead of increasing sedentary test-prep time, would do better if they increased students' heart-rates with physical activity. Movement gives learners spatial reference. Brains learn in short bursts followed by time to process the information. Motion releases the natural motivators dopamine and nonadrenaline. The nervous system fully matures between ages 15 and 20. As the years of development progress from childhood through adolescence, students need more breaks, not fewer. Students who jump rope or dance have been able to improve their math scores, probably because of the rhythmic nature of both activities. Aerobic activity should enhance students' endurance for the physical requirements of academic work (Jensen, 2000).

Kinesthetic activities, stated Moss and Fuller (2000), should be included in every lesson. It is important for teachers to believe that all students, regardless of preferred modality, have potential to learn (Moss & Fuller, 2000).

Mandinach and Cline (1993) wrote that a simulation modeling software package teaches problem skills, utilized in active learning. It allows students to develop active models of systems to explore phenomena (Mandinach & Cline, 1993).

According to Boxtel (2000), collaborative learning among students is enhanced by their shared use of textbooks. Collaborative lessons that utilize the text develop elaboration, use of prior knowledge, problem solving, and finding meaningful relationships. One of the most vital skills that students can develop in school is the ability to work with others. This is a skill that they will use in the workplace or at home (Boxtel, 2000).

According to Senge (1990), for team learning to be effective, assumptions should be suspended. We should examine the underlying assumptions that a strategy is based upon. A spirit of inquiry should support the asking of questions about evidence and thinking (Senge, 1990).

Role-playing activities, according to Resnick (1998), help students explore, in a participatory way, the behaviors of complex systems. This helps them to develop better intuitions on how complex phenomena can arise from simple interactions. Students can identify predictable patterns from random events (Resnick, 1998).

Crowdes (2000) stated that teaching is enhanced by attention to experiential and somatic learning models. The mind creates a relationship between private experience and social context. People find relationships between the world and their inner selves (Crowdes, 2000).

Guthrie, Schaffer, and Huang (2000) wrote that reading comprehension is increased by the amount of engaged reading. This is especially true when engaged reading is partnered with assessment and with a cognitive component. How do you become a good reader? By doing a lot of reading. Most of the things that people are good at are things that they do frequently. Although in many cases they may do the activity often because they are good at it, it also makes sense that they are good at the activity because of the frequency of their participation. Cognitive assessment increases the depth of participation, thereby increasing the volume of participation (Guthrie et al., 2000).

The literature on learning styles and ways implies that education should focus upon how individual learners internalize information in patterns that are linear or non-linear, concrete or abstract, and even random. It means that students learn by performing hands-on exploration, investigation, and discovery. It implies that students need to collaboratively and cooperatively examine data and issues.

This section has looked at how teachers' and students' preferred approaches, implementing and managing change, and mastery level accomplishment relate to styles and ways of learning. The next section will consider action research.

Action Research

In addition to learning styles, another characteristic of excellent education in general, and outstanding science education in particular is the consideration of action research. A proposed concept for a school may consider how teachers' and students' conduct of research, participation by teachers in the science community, and school life and growth are influenced by action research.

Administrators, according to Moller (1996), can become involved in action research in creative ways. Principals in schools in Norway are enabled by their dual role as teacher to use action research to develop educational leadership (Moller, 1996). Johnston and Proudford (1994) wrote that action research is negatively affected when administrators tamper with the process from their external position. Tensions are formed because most action research projects are externally funded and managed. This subjects teachers to expectations and top-down approaches of management that bring about difficulties which relate to the choice of topics, the time line, and the nature of the end product (Johnston & Proudford, 1994).

Atkin and Atkin (1989) found that in a scientist-teacher partnership, the scientist, by virtue of special knowledge and experience, serves as a valuable resource for the teacher engaged in action research. A scientist-teacher partnership allows a teacher to bring real-life problems and situations into the classroom, enhancing science education (Atkin & Atkin, 1989).

Calhoun (2002) proposed that whether action research is used as a school improvement tool or as an individual professional development option, faculty who draw on the current knowledge, and create knowledge-in-action, make instruction in the school or in the classroom more intentional and effective for student learning. When used as an organization-wide process for school improvement, action research changes the context and provides a way of organizing collective work, helping to build a strong learning community (Calhoun, 2002).

McNiff, Lomax, and Whitehead (1996) wrote that the achievement of educational excellence is a goal that action research and teaching should work together to achieve, but in reality this often is not what occurs. The values that educators hold and espouse are seldom lived fully in their practice; they are a living contradiction (McNiff et al., 1996). Dadds (1995) stated that when teachers do a 2-year, part-time advanced diploma on action research, they achieve professional development and personal growth, but not without struggling through a messy and frustrating process that puts them into a conflict between the needs of an academic discourse researcher and a practicing teacher. Research is an integral requirement for students and teachers (Dadds, 1995).

Action research, according to Lomas (1991), is implemented in individual classrooms and in entire schools. Action research can occur at a secondary school, middle school, preschool, or others. Action research could concern instruction, curriculum, lunchtime breaks, and other areas. The common thread of action research is managing and implementing change (Lomas, 1991). Action research, wrote Saurino (1994), is used to determine the effects of different evaluation formats for students of different levels of ability. All parts of the educational system can be improved by action research (Saurino, 1994).

Noffke (1997) stated that it is vital to see action research as interconnected spheres of the political, professional, and personal. Since the times when slaves were taught to read and write, action research has been a political activity. In another interpretation, action research is not intentionally political, but spans the gap between theory and practice or knowledge and action. Between these two conceptions is a third central purpose – action research is personal. The benefits are viewed as greater self-knowledge and fulfillment, deeper understandings, and development of relationships through collaboration (Noffke, 1997).

Feldman (1994) wrote that action research benefits teaching when it is an active and integrated part of teaching. If research activities are to have a lasting effect, they must be seen as an active part of teaching activities (Feldman, 1994). According to Zuber-Skerritt (1992), the research and the teaching should be interwoven. Teachers who are continuously involved in curriculum development and justification for their actions are incidentally engaged in professional development (Zuber-Skerritt, 1992).

According to Swanson and Finnan (1996), action research can begin with individuals or teams of teachers. One school restructuring approach is to promote change one classroom at a time. Another is to use an inquiry approach with teams of teachers to create school-wide change (Swanson & Finnan, 1996). An effective growth strategy, according to Caro-Bruce and McCreadie (1994), is to begin with a few teachers who are committed to action research, and then to grow out upon their success. In one school district, action research began with eight teachers and two facilitators, the next year it expanded to 24 teachers, then 38 teachers and four facilitators, and on to 46 teachers and 10 facilitators (Caro-Bruce & McCreadie, 1994).

Action research, noted Oja and Lewes (1989), is different than other types of research in that it is evaluated to a much greater extent based upon personal judgments and individual values. The personal nature of this evaluation is consistent with the nature of the action research process. The use of extended and personal examples by authors in their books on action research is a common feature, since action research commits its practitioners to learning from their own experience (Oja & Lewes, 1989). Benson, Harkavy, and Puckett (1996) stated that social sciences should help to solve the problems of our society. Universities should be reoriented toward helping solve the real-world problems of the local community through communal participatory action research. This will advance general knowledge and human welfare. The West Philadelphia Improvement Corps originated from an interest in three questions: How can social science contribute to society? What can be done to reduce the fragmentation of the social sciences? How can undergraduates learn and put their ideals into practice? (Benson et al., 1996).

McTaggart (1994) wrote that action research must be emancipatory; it must cause social action and educational reform. Teachers become emancipated, they emancipate their students, they engage in group collaboration, assume power, and become politically active. There is no other way to make progress toward authentic education for citizens (McTaggart, 1994). Kyle (1997) stated that action research is emancipatory when it aims to change the system and its conditions that impede improvement. Schools should undergo ongoing systemic change to meet students' needs. Each teacher should be expected to create fundamental change, as a model for students. Action research develops teachers who are flexible, critical, and reflective. Action research develops critical citizens who understand and change the world (Kyle, 1997).

Gustafson and Cichy (1996) wrote that action research has been used at a school for homeless families in Chicago, in community programs in Philadelphia, and regarding political issues such as at Watts, Harlem, and Selma. The best teacher is experience with reflection. Teacher candidates can keep journals of their recorded thoughts and actions. Their action research is always field based, using methods such as field notes, observation, interviewing, dialogue, audiotaping, and collecting students' work (Gustafson & Cichy, 1996).

The literature on action research implies that current knowledge and intentional instruction are attained when teachers conduct action research. It means that the dual role of principal and teacher resolves tampering by an external source in the conduct of action research. It implies that the scientist-teacher partnership brings real-life problems and situations into the curriculum.

This section has looked at how teachers' and students' conduct of research, participation by teachers in the science community, and school life and growth are influenced by action research. The next section will consider integrated curriculum.

Integrated Curriculum

In addition to action research, another characteristic of excellent education in general, and outstanding science education in particular is the consideration of integrated curriculum. The proposed plan for a school could consider how the alignment of curriculum, the reductionist worldview, and effective student advising are related to integrated curriculum.

According to Jasparro (1998), a systems approach to curriculum evaluation can produce better alignment among written, taught, and tested curriculum. Producers of textbooks write the curriculum, teachers instruct in the classrooms, and standardized tests are administered by services. Politicians, administrative specialists, and society are also involved. The coordination between these groups is unorganized and limited. A coordinated effort between writers, teachers, and testers would greatly improve efficiency and enhance quality by focusing all parties onto shared goals for education (Jasparro, 1998).

Gilbert and Boulter (2000) wrote that a model in science forges a link between a theory and a phenomenon. Science is the focal point to form various other disciplines into a whole education (Gilbert & Boulter, 2000).

Capra (1982) proposed that perception of reality is moving away from the traditional reductionist, mechanical worldview to an ecological, holistic, and systems paradigm, consistent with an integrated curriculum. Traditional education has sought simple explanations for complex phenomena. Yet, reality does not conform to education's rules. Lithification is a chemical process, occurring within the Earth, which bonds the remnant shells of animals to form rocks, so is it the subject of chemistry, geology, or biology? Slavery provides a simple explanation, but it may not have been the primary cause for the Civil War. Biology is taught before geology, which is taught before physics, because "B" comes before "G", which comes before "P" (Capra, 1982).

Ayalon (2002) found that a restricted curriculum enhances socioeconomic, ethnic, and gender equality in course taking and achievement. Students who belong to privileged social groups join the more valued, more attractive, and more rewarding courses. In an unrestricted curriculum, males are two to three times as likely as females to be enrolled in physics and chemistry (Ayalon, 2002).

According to Klien and Rutherford (1985), in a spiral curriculum, as used by Japan and Germany, each science is taught over a period of several years, to build an intuitive understanding and finally to progress to abstract, theoretical analysis. The U.S. practice of one year, one subject promotes superficial thinking and rapid forgetting (Klien & Rutherford, 1985).

Curriculum planning and effective advising, wrote Cotter (1998), will help students develop intellectual connections across courses. The curriculum of different disciplines needs to be coordinated so that the relationships of concepts are presented. Coordination should be used to prevent unwanted overlap or gaps between courses (Cotter, 1998).

Musschenga and Gosling (1985) noted that the models of science curriculum are product, inquiry, and relevance. Product aims to impart an unproblematic body of knowledge about the natural world. Inquiry aims to satisfy curiosity about the way the world is. Relevance aims to acquire knowledge for the sake of collective liberation and personal development (Musschenga & Gosling, 1985).

Weertz (2002) commented that a science-themed elementary school in Michigan was inspired because the teachers were not enthusiastic about science. They were shying away from teaching science, or they were just teaching it from the book. Getting theme school status was a way to get support for science instruction (Weertz, 2002).

Matthews (1998) commented that courses in the history and philosophy of science are necessary. Curriculum should help students to understand the historical significance of science (Matthews, 1998).

Bohm (1979) wrote that only laws that apply to many cases, utilizing inward perception, risk the step toward insight. Students should study integrated curricula in which these universal laws are taught. They should then be encouraged to consider the laws to possibly develop insight. Relying upon outward perception is ultimately inadequate. Inward perception may bring us into contact with new forms and areas of reason. Insight is understood by looking at theories that deal with universal laws that have significance for the totality, independent of conditions. Outward perception is used to explain events that are experienced. Alternative explanations are readily developed. On a regular basis, explanations based upon outward perception are disproved by new discoveries (Bohm, 1979).

Sherman (2002) proposed that connecting science to mathematics content is a key to strengthening and enhancing learning. This link is critically important to improving mathematics and science achievement throughout the educational system (Sherman, 2002).

Science, commented Postman (1995), is not physics, biology, or chemistry. It is not even a subject. Science is a moral imperative drawn from a larger narrative whose purpose is to give perspective, balance, and humility to learning (Postman, 1995).

There is a new awareness, posited Lickona (1991), that the science curriculum has been a sleeping giant. We are missing a great opportunity if we fail to use the academic curriculum as a vehicle for developing values and ethical awareness (Lickona, 1991).

Three stages of creativity, according to Rose and Nicholl (1997), are insight, when you decide which clues are important; combination, when you recombine ideas in a new way; and evaluation, which requires perseverance to see the idea through implementation. Insight, combination, and evaluation can be utilized to approach a technical science problem from a social perspective, to approach an artistic problem from a mathematical perspective, to conceive relationships between literature and science, to conceive relationships between music and athletics, to compose music, to achieve a scientific breakthrough. Turning the problem upside down can inspire creative thinking;

Instead of asking why do people get smallpox, Edward Jenner discovered the immunization for smallpox when he asked why dairymaids did not get the disease. Adapting can inspire creative thinking; the Wright Brothers watched buzzards and noticed how the birds not only dropped but also twisted their wings, which led to their development of the aileron. Allowing the imagination to float freely can inspire creative thinking; Friedrich August Kekule came up with the structure of the benzene molecule when, relaxing before a fireplace, he dreamed of flames that turned into snakes, one of which seized its own tail (Rose & Nicholl, 1997).

Rose and Nicholl (1997) wrote that when Albert Einstein came to the end of the road or into a difficult situation, he would take refuge in music.

> Playing the violin put him into a peaceful state of mind, which facilitated his reflection, leading to the answer to a physics problem. Music excites the inherent brain patterns and enhances their use in complex reasoning tasks. In the current debate on the need to raise educational standards, it would be a mistake to narrow the focus to just English and mathematics. (Rose & Nicholl, 1997, p.181)

In a multi-media world, stated Ohler (2001), art is as basic as reading, writing, and arithmetic. The Internet requires students to think and communicate as artists and as designers. Students, struggling on the Web to use video clips, sound buttons, and graphics, would benefit from art instruction (Ohler, 2001).

From birth and throughout life, wrote Hodges (2000), the brain responds to and participates in music. Musical training affects the organization of the brain. Music establishes the emotional environment for learning. Music can be used to reduce distractions such as talking and outside noise. Music can be a language by which some students can most effectively learn and demonstrate learning. Some classical music, particularly pieces that use innovative and complex note patterns, feel invigorating, and intuitively seem to be catalysts for the development of mental structuring (Hodges, 2000).

The literature on integrated curriculum implies that shared goals are achieved by the alignment between written, taught, and tested goals. It means that a spiral curriculum progresses from an intuitive knowledge into abstract analysis without superficiality and massive forgetting. It implies that socioeconomic, ethnic, and gender equity can be attained by an integrated curriculum.

This section has looked at how the alignment of curriculum, the reductionist worldview, and effective student advising, are related to integrated curriculum. The next section will consider theories of learning.

Theories of Learning

In addition to integrated curriculum, another characteristic of excellent education in general, and outstanding science education in particular is the consideration of theories of learning. Accelerated learning and memory methods, and their influence on theories of learning, may be considered in the proposed design for a school.

Learning becomes successful and enjoyable, wrote Rose and Nicholl (1997), through ensuring the subject is relevant, ensuring the learning is emotionally positive, involving all of the senses, thinking through and exploring with many intelligences, and by reviewing in relaxed alertness. The six-step MASTER plan for accelerated learning is to Motivate the mind, Acquire the information, Search out the meaning, Trigger the memory, Exhibit what you know, and Reflect on how you've learned (Rose & Nicholl, 1997).

According to Rose and Nicholl (1997), accelerated learning strategies for acquiring information are to get the big picture, establish the core idea, sketch out what you know, learn one small step at a time, and to keep asking questions. Personal learning styles include Visual, learning through seeing, using learning maps, visualizing; Auditory, learning through hearing, reading aloud, drama; and Kinesthetic, learning through physical activities, writing, learning in groups. The VAK Attack is used to achieve accelerated learning by the use of Visual, Auditory, and Kinesthetic communications (Rose & Nicholl, 1997).

Rose and Nicholl (1997) stated that people tend to remember more of the beginning, and also more of the ending of any learning session, so to keep recall high there should be plenty of beginnings and endings. Taking brief breaks, at intervals not exceeding 20 minutes, will boost the amount of material retained. Studying one hour per day for 7 days will produce more learning than studying for 7 hours in one day. Things you learned during the day are filed away when you sleep, so learning, reviewing before sleep, sleeping, and then reviewing the previous day's work will produce accelerated learning (Rose & Nicholl, 1997).

The transformational theory of learning, according to Mezirow (1996), is based upon an emancipatory paradigm. It constitutes a dialectical synthesis of objectivist and interpretive paradigms. Transformational theory claims distinction between instrumental and communicative learning, particularly the roles of critical reflection and discourse in human communication, and interpretive frames of reference. A vital element to the usefulness of participatory learning is the opportunity for the student to reflect critically on his or her experience. This should be unhurried, and with a minimum of influence from the facilitator (Mezirow, 1996).

Caine and Caine (1990) found that because of the vastness, complexity, and the potential of the human brain, brain-based learning is needed. Brain-based learning is based upon the principle that the brain is a parallel processor. The brain ceaselessly performs many functions simultaneously (Caine & Caine, 1990). Caine and Caine (1997b) wrote that brain-based learning is based upon the principle that the brain is a complex neurological organ. Learning engages the entire physiology that brain-based learning accommodates a reality that is much more fluid, less predictable, and more interconnected than previously understood (Caine & Caine, 1997b). Caine and Caine (1995) also wrote that brain-based learning utilizes learning communities in which students can experience and test many of the relationships and ideas they will need in the real world, in a safe, nurturing context. This is especially beneficial to children who come from low socio-economic, and often, dysfunctional families (Caine & Caine, 1995).

The literature on theories of learning implies that lessons need to be relevant and emotionally positive, utilizing the senses and the intelligences of individual students. It means that projects can be used to provide objective and interpretive knowledge. It implies that learning flourishes in communities where ideas are shared in safety.

This section has looked at accelerated learning and memory methods, and their influence on theories of learning. The next section will consider diversity students.

Diversity

In addition to theories of learning, another characteristic of excellent education in general, and outstanding science education in particular is the consideration of diversity. The proposed concept for a school could look at how shared values and beliefs, equal opportunity, and increased requirements for teachers and facilities, may be related to diversity.

Student populations in the future, according to Hall and Parker (1993), will include more people of color, more women, and more learners with special needs. Programs to meet their special needs will require support (Hall & Parker, 1993).

A multicultural science curriculum, posited Zarry (2002), would more fully equate the concepts of nature and science, and the benefits of living with nature, as advocated by the Aboriginals and the Japanese. Eurocentric science reasons that control over nature, made possible by science, proves that European thought correlates most closely to the underlying realities of the universe. Supporters of Eurocentric science argue that it provides a superior knowledge of the natural world as compared to mythical or heretical views (Zarry, 2002).

Barr and Birke (1998) commented that most people must recognize that science permeates our lives. Yet many people and most women stand outside science. To study science it helps to be male, middle-class, heterosexual, and from an industrialized country. Women's alienation stems from the way science is taught in school. The relatively rigid methods of science teaching do not take account of differences in learning style (Barr & Birke, 1998).

According to Shymansky, Hedges, and Woodworth (1990), there is a trend between the number of years of participation in a hands-on program of science education and stronger science scores on standardized tests. The benefits are greatest for children from lower socioeconomic and rural backgrounds (Shymansky et al., 1990).

Bredo, Henry, and McDermott (1990) stated that classroom language is how teachers and students talk with each other in classrooms. Problems related to classroom language faced by minority students and their teachers are caused by cultural differences in the communication skills that they bring to school (Bredo et al., 1990).

Allchin (1999) noted that cultural values guide science progress. The social structure of science is strengthened by a diversity of values. Science exports values to the culture. Understanding the relationships between science and values helps students in fully appreciating the nature of science (Allchin, 1999).

Kozol (1997) wrote that tracking, which isolates social classes, should be outlawed. All students should have an equal opportunity to attend the classes of their choice (Kozol, 1997). Kozol (1992) also wrote that vouchers benefit children of the most wealthy or best educated. They are the ones who hear about new schools and good schools first (Kozol, 1992).

According to Davies (2000), 65% of disadvantaged students are likely to fail high-stakes tests. Success, in an environment where standardized testing can determine if a student graduates or is retained, requires a powerful partnership between educators and parents (Davies, 2000).

According to Sarason (1990), public school students, overwhelmingly children of color and children of the poor, are cheated out of even an adequate education. In urban schools, less than half of the students graduate, and less than a third can read at grade level (Sarason, 1990). Sarason (1997) also noted that it will take many decades for disadvantaged students to improve their performance on school achievement and other cognitive tests as long as they lack a context for productive learning. This will require changes outside the schools, as well as in the classrooms (Sarason, 1997).

Walters, McCammon, and James (1990) wrote that participation in education has been affected by society. In the southern United States a century ago, the coerciveness of racial segregation and child labor depressed the supply of and demand for education, and plantation agriculture especially lessened the educational opportunities for Blacks (Walters et al., 1990).

Genetic factors, wrote Gardner (1993), set some kind of upper bound on intelligence, rarely approached. There might be differences across groups. Apparent group differences have been exploited for politically dubious ends. Group differences should not be regarded as any kind of proof of inherent group limitations (Gardner, 1993).

This section has looked at how shared values and beliefs, equal opportunity, and increased requirements for teachers and facilities, may be related to diversity. The literature on diversity implies that programs that promote participation in science education by people of color, women, and those with special needs, require greater recognition and support. It means that a multicultural curriculum reconciles the purposes of science and nature. It implies that laboratory experiments improve scores on standardized tests, especially for low socioeconomic students. The next section will consider intelligences.

Intelligences

In addition to diversity and disadvantaged students, another characteristic of excellent education in general, and outstanding science education in particular is the consideration of intelligences. The proposed concept for a school may address how development of outstanding individuals, alternative educational settings, the assessment of valued life skills, the management of stress, approval and encouragement of adults, and effective criticism relate to intelligences.

Gardner (1993) stated that multiple intelligences are a set of abilities, intelligences, or mental skills. They are identified by knowledge about normal development, gifted development, information about brain damage, cross-cultural accounts of cognition, correlations among psychological tests, and psychometric measures of transfer and generalization across tasks. The multiple intelligences are linguistic, logical-mathematical, visual-spatial, bodily-kinesthetic, musical, interpersonal, intrapersonal, naturalist, moral-spiritual, and artistic (Gardner, 1993).

Gardner (1993) provided examples of multiple intelligences: Yehudi Menuhin, when 3-years-old, insisted on a violin and a concert violinist instructor for his birthday. By the time he was 10 years old, he was an international performer. His powerful reaction and rapid progress suggest he was biologically prepared. Navigators in the Caroline Islands cannot see the islands; they use the positions of the stars, the weather patterns, and the color of the water to "see" the islands, mapping their locations in a mental "picture" of the journey. Anne Sullivan disciplined Helen Keller without breaking her spirit. She noticed subtle distinctions in Helen's behavior to read her intentions and desires. Virginia Woolf contrasted the "cotton wool" of life with three memories from her childhood: a fight with her brother, seeing a flower in the garden, and hearing of the suicide of a past acquaintance. She illustrated her access to her own feeling life, her range of emotions, her understanding of her own behavior (Gardner, 1993).

In traditional schools, according to Gardner (1993), there are regular assessments using paper and pencil. Schools should recognize facets of cognition and styles. A more naturalistic view of intelligence would look at sources of how people develop skills important to their life. Sailors, surgeons, dancers, and sorcerers solve problems, or fashion products that are valued. Verbal and mathematical skills alone may not determine your ability to do well after you leave college (Gardner, 1993).

In the future, according to Gardner (1993), neuroscientists will know more about the organization and development of the nervous system. Future genetic studies will reveal whether individual strengths are under the control of individual genes or gene complexes. We will have a greater store of educational technologies. In the future, there will be a wider acceptance of the notion that intelligence deserves to be pluralized (Gardner, 1993).

Hartman and Sternberg (1993) wrote that factors that influence intellectual performance are behavior, attitudes, cognition, and the environment as interacting systems. A system that does not respond to individual needs with regard to each of these factors will not serve the needs of the majority of students. The sometimes-complex relationships between these factors should also be carefully considered. Teaching behavior such as study skills does not address the attitude of some students that learning does not require their active participation. Developing cognitive knowledge of musical nomenclature does not affect an individual whose family does not value the arts (Hartman & Sternberg, 1993).

Over the past decades, according to Schon (1992), there has grown a crisis of confidence in the education profession. Skepticism has grown about the beneficence and utility of knowledge. At the heart of the crisis is a widening gap between thought and action (Schon, 1992).

According to Gardner (1993), the explanatory importance of general intelligence is questionable. General intelligence tests are short-answer, switch-from-one-context-to-another-as-quickly-as-you-can, do-it-in-half-an-hour instruments. Performance on a general intelligence test is relevant to school success, but not much else that is important or valued in society (Gardner, 1993).

Emotional Intelligence (EI), stated Goleman (1995), is the ability to motivate oneself and persist in the face of frustrations, to control impulse and delay gratification, to regulate one's moods and keep distress from swamping the ability to think, to empathize and to hope. The emotional centers of the brain have immense power to influence the functioning of the centers for thought. The ability to deny impulse in the service of a goal is the essence of emotional self-regulation. People who are adept at harnessing their emotions use anticipatory anxiety to motivate themselves to do well (Goleman, 1995).

Goleman (1995) wrote that all the small exchanges between adults and children form an emotional subtext. Children who have received a goodly dose of approval and encouragement from the adults in their lives expect to succeed; almost all children who do not receive this expect to fail and they do poorly in school. Success in school depends on knowing how to learn. This consists of confidence, curiosity, intentionality, self-control, relatedness, capacity to communicate, and cooperativeness (Goleman, 1995).

Goleman (1995) stated that social abilities allow one to shape an encounter, to mobilize and inspire others, to thrive in intimate relationships, to persuade and influence, and to put others at ease. One social competence is how well people express their own feelings. We send emotional signals in every encounter, and those signals affect those we are with. Interpersonally intelligent people are considered a pleasure to be around (Goleman, 1995).

Attunement, stated Poulsen and Fouts (2000), is a dance of emotional experience that allows a teacher and a student to relate to each other, and to learn from one another. Learning is enhanced when the teacher is aware of the emotional states of students, and responds favorably to their conditions. In traditional schools, it is understandable that scrutinized, mistrusted, or overburdened teachers may pass on some of their emotional discontent to their students (Poulsen & Fouts, 2000).

Developing an intentional relationship, stated Peterson (2001), requires that teachers pay attention to each of the students in front of them. It is an effective method for reaching a difficult student. The teacher asks, “What can I do to help you?” and also, “What can you do to help me?” Disruptive students transfer the hateful feelings they have for others to teachers whom they do not know. When a relationship with a teacher is developed, the student's emotional outbursts directed at this teacher no longer seem to be deserved. The result is often an opening and a softening of the student-teacher relationship. Typically, students respond to this simple attempt to make contact by being quieter, by bringing their book, and by finding their ways to participate in learning (Peterson, 2001).

Emotions that simmer beneath the threshold of awareness, according to Goleman (1995), have a powerful impact. Those who have a natural attunement to their own heart's voice--the language of emotion--are sure to be more adept at articulating its messages, whether as a novelist, songwriter, or psychotherapist. Self-awareness is a neutral mode that maintains self-reflectiveness, even amidst turbulent emotions. Mindfulness helps the emotionally attuned to manage their emotions (Goleman, 1995).

Empathy, wrote Goleman (1995), the capacity to know how another feels, comes into play in a vast array of life areas, from sales to romance to political action. From repeated attunements a child develops a sense that other people can and will share in his or her feelings. Empathy underlies many facets of moral judgment and action (Goleman, 1995).

Cobb and Mayer (2000) wrote that Emotional Intelligence (EI) is an alternative concept to the established Intelligence Quotient (IQ). EI measures awareness of emotions, persistence and zeal, and good behavior. It integrates the head and the heart. Developing EI in schools would result in a place where students feel respected, cared about, and bonded to their classmates. The assumption for traditional schools is that their mission is to provide knowledge, to increase the intelligence of their students. Students develop pride when they demonstrate that they are capable of making a difference (Cobb & Mayer, 2000).

The literature on intelligences implies that genetic and neuroscience discoveries will validate the concept of multiple intelligences. It means that the development of multiple abilities and mental skills that are important to life should be the focus of education. It implies that emotional intelligence, the ability to motivate and to persist, to tolerate frustrations and to delay gratification, affects academic performance.

This section has looked at how development of outstanding individuals, alternative educational settings, the assessment of valued life skills, the management of stress, approval and encouragement of adults, and effective criticism relate to intelligences.

This chapter of the dissertation has looked at the literature on general education and the literature on science education. It has reviewed the topics of systems thinking, accountability and assessment, small classes and schools, leadership, learning environment, organizational change, effective teaching, learner-centered classrooms and schools, learning styles and ways, action research, integrated curriculum, theories of learning, diversity and disadvantaged students, and intelligences. The next chapter of the dissertation will discuss the methods that were used to conduct the research.

CHAPTER THREE: Research Methods

This third chapter of the dissertation will provide a description of the research design, a review of the mixed-methods research approach, a description of the setting, participants, procedures, research instruments, and the planning phase.

Action Research

This study represents the beginning phase of a larger action research project. Many theoretical models have influenced the design of this study, the most influential being action research.

Miller and Bench (1996) stated that a five-step process for action research involves picking a problem, determining one's knowledge, collecting and analyzing data, reporting results, and planning actions. Action research is an approach in which teachers reflect on their work, seek feedback from colleagues, and make changes in their practice (Miller & Bench, 1996). McNiff, Lomax, and Whitehead (1996) wrote that action research is effectively validated by sources and methods that are common to other forms of research. Validation of action research can be by self, peer, administration, students, or the academic community (McNiff et al., 1996).

According to Zuber-Skerritt (1992), the teacher's actions and intentions, and the student's responses should be recorded on tape. It is important that action research is an ongoing program (Zuber-Skerritt, 1992). Borgia and Schuler (1996) stated that validity in action research should be obtained from at least three different sources such as journals, portfolios, and tape recordings; this is a method known as triangulation. Their components of action research are the five Cs: Commitment, Collaboration, Concern, Consideration, and Change (Borgia & Schuler, 1996).

Joyce and Calhoun (1996) wrote that action research has grown to include a requirement for collaboration, a prerequisite determination of the knowledge base, and a need for a consideration of human values. They believed that action research programs should share these characteristics: a focus upon student learning, an investment in people, and a commitment to generating knowledge (Joyce & Calhoun, 1996).

According to Sparapani (1996), action research is generally not transferable; it is bound to a particular setting and circumstances. It is used to connect classroom practice to theory (Sparapani, 1996).

Action research, wrote McNiff, Lomax, and Whitehead (1996), is used to improve most areas of teaching. A focus for action researchers can be to determine how to improve what they are doing in their own teaching (McNiff et al., 1996).

Pedretti and Hodson (1995) wrote that extending horizons and building professional confidence are the most important outcomes of action research. Using action research to improve the education process teacher by teacher seems to be society's best assurance for preparing productive, competitive high school graduates (Pedretti & Hodson, 1995).

Calhoun (1993) wrote that school-wide action research involves an entire faculty. School-wide action research, in addition to being a problem-solving entity, improves equity for students, and increases the breadth and content of the inquiry itself (Calhoun, 1993).

This study involved the action research steps of picking a problem, determining one's knowledge, collecting and analyzing data, and reporting results. It forms the basis for the next action research step, a plan for action, the proposed design for a science-centered magnet school, which is partially developed in this dissertation.

Research Design

For this research study I collected survey data, performed interviews, and conducted focus groups. I surveyed 412 students and 218 parents or guardians. The students were enrolled in high school science classes, and the parents or guardians were their parents or guardians. I conducted interviews and focus groups with science teachers, educators, and scientists. The surveys presented 12 factors, some of which I believed to be valued by some individuals as part of an excellent science education, or education in general, and some were included to stimulate thought and discussion. The factors were security, social activities, sports, computers, reading and writing, hands-on experiments, small class size, qualified instructors, classroom facilities, laboratory equipment, industry support, and cafeteria. These are the factors that students, parents, educators, and experts have discussed with me when we have talked about quality education and science instruction during my 10 years as a public school teacher. The survey participants rated each factor from most important to least important. The focus groups and the interviews covered science education in general, as well as some of these same 12 topics.

The goal of my study is to establish what students, parents or guardians, and experts in the community desire for excellent science education. The research question is: What is desired for quality science education?

The Setting

The high school science students, their parents or guardians, the teachers, the educators, and the experts who participated in this study are residents of a small community in a western state. This area has a population of approximately 67,000. Ethnicity in the community is 50% Hispanic, 10% African American, and 40% Caucasian. Residents mostly are retired or commute to their employment. The unemployment and the poverty rates for this area are double the state average. The students attended a high school that has a population of approximately 2,700 students, and is ranked in the lower 30th percentile of scholastic achievement by statewide standardized testing. To provide confidentiality in the dissertation, the community and the school are not named.

Survey Participants

The participants in the survey were high school science students who were preparing for entrance into college. They were selected for this study because of the significance of science education at that time for these participants. The participants' ages range from 14 to 18 years. Ethnicity in the study and in the school is 60% Hispanic, 20% African American, and 20% Caucasian. There are approximately equal populations of male and female participants. To provide confidentiality, in the dissertation I only identify the participants as students and as parents or guardians. I do not and will not disclose the names of the participants.

Students who participated in the survey were recruited from the science classes that I teach. Parental consent was required, since many of the student participants were minors.

Parents or guardians of these students were recruited to participate in the survey. I provided details of the study to participants to obtain informed consent. The participation of students from other science classes and their parents or guardians was also welcomed.

For the survey, approximately 750 students and their parents or guardians were asked to participate. An acceptable number of responses was attained. Only one parent survey per student was accepted, although parents or guardians were allowed to collaborate on their responses.

Participants in Focus Groups

The participants in the focus groups were high school science teachers at the high school where I teach, educational leaders, and experts in the field of science, requested from among members of the community. I considered individuals to be experts based upon their positions of importance as scientists. Members of these groups had a minimum of 3 years, and an average of 8 years of teaching or career experience. To provide confidentiality, in this dissertation, educators and experts are not individually named. I only identify the participants as educators and by the subjects that they teach, or as experts and by their professions. I did not and will not disclose the names of the participants.

A cosmetologist, a nutritionist, and a zoologist were the experts who participated in a focus group. It was intended that the experts would form a spectrum of science including scientists in pure forms such as biologist, chemist, and physicist, as well as some of science's more accessible manifestations such as physician, nutritionist, and cosmetologist.

Seven educators participated in focus groups. A biology teacher, a life science teacher, a physical science teacher, a physics teacher, an anatomy and physiology teacher, a special education teacher, and a teacher's aide, participated in focus groups.

The participants in the focus groups were asked to discuss their responses to questions that relate to science education in general, as well as the survey topics. Participation in an interview or a focus group format was determined by practical considerations relating to the needs of the participants.

For the focus groups, teachers were asked to attend one-hour group meetings, held at the school site, during hours immediately adjacent to the times that they teach. Scientists met at a convenient location and time. Educators and experts were recruited using a letter (see Appendix F) and a follow-up telephone call.

Participants in Interviews

The participants in the interviews were high school science teachers at the high school where I teach, educational leaders, and experts in the field of science, requested from among members of the community. To provide confidentiality, in the dissertation educators and experts were not individually named. I only identify the participants as teachers and by the subjects that they teach, as educators and by their position, or as experts and by their professions. I did not and will not disclose the names of the participants.

Seven experts participated in interviews: an astronomer, a biologist, a chemist, a geologist, a physician, a physicist, and a psychologist. Three educators participated in interviews: a mentor teacher, a principal, and a school board member. The participants in the interviews were asked to discuss their responses to questions that relate to science education in general, as well as the survey topics.

For the interviews, participants were asked to give one-hour personal interviews at their place of work, their home, or other suitable location at their convenience. Educators and experts were recruited using a letter (see Appendix F) and a follow-up telephone call.

Survey Procedures

I gave surveys to students and their parents or guardians at a high school, with the permission of the principal. I distributed and collected the surveys. The students completed a survey at home. They also took a survey home to their parents or guardians. Students returned the surveys to me at the school.

For the survey, 12 versions were used, with the items rotated so that each appeared first, last, and in each other ordinal position. Surveys that were not properly completed, according to the instructions given, were excluded. I prevented bias and coercion by avoiding discussion with the participants regarding the content of the survey prior to its completion.

Procedures for Focus Groups

For the focus groups, full verbatim transcripts were created. For the focus group meetings, I asked questions about education in general, I suggested topics to discuss, and I asked questions and follow-up questions, but I did not provide my views or opinions during the discussions. Discussion topics in addition to science education in general were the importance to science education of small class size, qualified instructors, classroom facilities, laboratory equipment, industry support, computers, reading and writing, hands-on experiments, security, cafeteria, social activities, and sports. Open-ended discussion questions were developed based upon guidelines provided by Weiss (1994).

Procedures for Interviews

For the interviews, full verbatim transcripts were created. For the interviews, I asked questions about education in general, I suggested topics to discuss, and I asked questions and follow-up questions, but I did not provide my views or opinions during the discussions. Discussion topics in addition to science education in general were the importance to science education of small class size, qualified instructors, classroom facilities, laboratory equipment, industry support, computers, reading and writing, hands-on experiments, security, cafeteria, social activities, and sports. Open-ended discussion questions were developed (see Appendix E) based upon guidelines provided by Weiss (1994).

Survey Research Instruments

Science students and their parents or guardians received a three-page survey package. The first page is a statement of consent or assent (for parent surveys, this is preceded by a cover page). Participants were asked to sign this page. The second page is a brief introduction, instructions, and a sample survey. This provided directions to participants so they could provide valid responses to the survey. The final page is the survey. Twelve factors that I believe contribute to excellent education were listed. Before each factor is a small blank line. The participants wrote the numbers 1 through 12 on each line to indicate which item they considered to be most important (1) through least important (12) for an excellent science education. They responded to the following terms: security, social activities, sports, computers, reading and writing, hands-on experiments, small class size, qualified instructors, classroom facilities, laboratory equipment, industry support, and cafeteria.

For statistical analysis of the data, I calculated the mean average score, the standard deviation, the t-score, and the p-score for each of the 12 items. I ranked the items 1 (most important) to 12 (least important) according to their average score. I performed this analysis at three levels: for students and parents or guardians combined, and separately for students and for parents or guardians. I determined which items students and parents or guardians agreed are most important, and which they agreed are least important. I determined which items students and parents or guardians disagreed upon most, and by how much they disagreed. I determined which items were ranked first most often by students, by parents or guardians, and by students and parents or guardians combined. I used SPSS software, and guidelines provided by Becker (1998), to support quantitative analysis of the information attained from the survey (see Appendix A for copies of the surveys, Appendix B for a copy of a sample survey, Appendix C for copies of the consent or assent forms, and Appendix D for a copy of the request for permission to survey).

Research Instruments for Focus Groups

For the focus groups, experts and science teachers were asked to attend one of several meetings. I led the group discussions using questions about science in general and also an outline of subjects that I would have liked for them to discuss. Their responses were recorded on audiotape. I used QSR N4 NUD*IST software, and guidelines provided by Gahan and Hannibal (1998), to support qualitative analysis of the information attained from the focus group meetings (see Appendix E for the discussion questions for focus groups).

Research Instruments for Interviews

For the interviews, experts and science teachers were asked to provide interviews. I conducted the interviews using questions about science in general and also an outline of subjects that I would have liked for them to discuss. Their responses were recorded on audiotape. I used QSR N4 NUD*IST software, and guidelines provided by Gahan and Hannibal (1998), to support qualitative analysis of the information attained from the interviews (see Appendix E for the discussion questions for interviews).

Planning Phase

The open-ended discussion questions to be used for the focus groups and the interviews were developed based upon guidelines provided by Weiss (1994). Weiss said that the interviewer wants to show that he or she wants to learn and is worth teaching, and that he or she knows something, but not everything. Weiss characterized a qualitative interview as different than an ordinary conversation in that you pin people down by asking for specifics.

Weiss said that prior to an interview he lists the 10 to 12 things that he wants answered. According to Weiss, the determinants of the questions to be asked in an interview are the problem to be researched, the breadth and depth of the material to be collected, the repertoire of understandings based upon previous work, study, awareness of the literature, and experience in living, and a sense of what will give substance to the eventual report.

This chapter has looked at the methods that were used to conduct a survey, focus groups and interviews. The next chapter will review the results of that research.

CHAPTER FOUR: Results and Discussion of the Research

This fourth chapter will present and discuss the results of the survey, and the outcomes of the interviews and the focus groups. These results are presented to establish what factors the participants desired in relation to providing quality science education.

Survey Results

A total of 630 participants completed the surveys: 412 students and 218 parents or guardians. The participants were high school students in my science classes, and their parents or guardians. I showed the students how to rank the items, using the sample survey. Students took their surveys, sample surveys, and parent surveys home. All participants ranked 12 items from 1 for most important, to 12 for least important to provide quality science instruction. Students then returned the completed surveys to me.

When the results of students' and parents' surveys were combined (weighed equally; see Table 1), the items that they ranked as most important were qualified instructors (mean average score and rank, 4.14, 1st), hands-on experiments (5.34, 2nd), and computers (5.80, 3rd). The importance of qualified instructors was justified in the literature by Duschl (1990), Starnes (2000), Taylor (1987), and others. The importance of hands-on experiments was justified in the literature by Gardner (1993), Gilbert and Boulter (2000), Martin (1994), and others. Items that were also important to students and parents were reading and writing (5.82, 4th), classroom facilities (5.92, 5th), and laboratory equipment (5.93, 6th). The importance of reading and writing was justified in the literature by Boxtel (2000), Guthrie, Schaffer, and Huang (2000), Matthews (1998), and others.

The items ranked first most often by students and parents (weighed equally; see Table 2) were qualified instructors (30.5%, 1st) and security (15.2%, 2nd). Sports (11.3%, 3rd) and reading and writing (10.3%, 4th) were also ranked first most often. The importance of sports was justified in the literature by Flowerday and Schraw (2000), Jensen (2000), Moss and Fuller (2000), and others.

Discussion of the Research

Students (see Table 3) and parents (see Table 5) agreed that qualified instructors (5.16, 1st; 3.12, 1st) is the item that is most important to provide quality science instruction. They agreed when they ranked hands-on experiments (5.44, 2^{nd}; 5.24, 3^{rd}) in their top three responses, and laboratory equipment (6.18, 5^{th}; 5.67, 5^{th}) and classroom facilities (6.27, 6^{th}; 5.57, 4^{th}) in their leading six responses among the 12 items that they ranked.

Students (see Table 3) and parents (see Table 5) agreed that cafeteria (8.69, 12^{th}; 9.77, 12^{th}) is the item that is least important to provide quality science instruction. They agreed when they ranked industry support (8.19, 11^{th}; 8.14, 9^{th}), sports (6.40, 7^{th}; 9.07, 11^{th}), and security (6.50, 8^{th}; 6.47, 8^{th}) in their lowest six responses among the 12 items that they ranked.

Students (see Table 3) and parents (see Table 5) disagreed most on the item reading and writing, which students ranked 9th (6.86), but parents ranked 2nd (4.78), a difference of 7 rankings. They disagreed on social activities, which students ranked 4th (5.70), but parents ranked 10^{th} (8.47), a difference of 6 rankings. The importance of social activities was justified in the literature by Goleman (1995), Postman (1995), Rose and Nicholl (1997), and others. They also disagreed on computers, which students ranked 3rd (5.59), but parents ranked 7th (6.00), on sports, which students ranked 7th (6.40), but parents ranked 11th (9.07), and on small class size, which students ranked 10th (7.02), but parents ranked 6th (5.70), each a difference of 4 rankings. The importance of small class size was justified in the literature by Rockman (1987), Sizer (1996), Wasley (2002), and others.

Considering only the item that was ranked 1st, students (see Table 4) identified sports most often (19.7%) as most important, but parents (see Table 6) disagreed and ranked this 8th (3.2%), a difference of 7 ranks. Parents ranked qualified instructors most often (42.7%) as most important, and students ranked this item 2nd (18.9%), a difference of only 1 rank.

Still considering only the item that was ranked first, students (see Table 4) and parents (see Table 6) both identified security (13.1%, 3rd; 17.9%, 2nd) in their top three most often as most important. They agreed when they identified hands-on experiments (9.2%, 4th; 6.4%, 4th) and reading and writing (8.5%, 5th; 12.4%, 3rd) in their top six. They disagreed when students identified social activities in their top six (6th, 8.3%), but parents rated this item last (12th, 0.9%).

Student and Parent Surveys

When the results of students' and parents' surveys were combined (weighed equally; see Table 1), the items that they ranked as most important were qualified instructors (mean average score and rank, 4.14, 1st), hands-on experiments (5.34, 2nd), and computers (5.80, 3rd). Items that were also important to students and parents were reading and writing (5.82, 4th), classroom facilities (5.92, 5th), and laboratory equipment (5.93, 6th).

Items that were ranked as less important when the results of students and parents were combined were small class size (6.36, 7th), security (6.49, 8th), and social activities (7.09, 9th). Items that were least important to students and parents were sports (7.74, 10th), industry support (8.17, 11th), and cafeteria (9.23, 12th).

Table 1

Student and Parent Surveys

The results of students' and parents' surveys combined (weighed equally) are as follows:

Most Important:

Total Rank: 1 – Qualified Instructors – Mean Average Score: 4.14.

Total Rank: 2 – Hands-On Experiments – Mean Average Score: 5.34.

Total Rank: 3 – Computers – Mean Average Score: 5.80.

Also Important:

Total Rank: 4 – Reading and Writing – Mean Average Score: 5.82.

Total Rank: 5 – Classroom Facilities – Mean Average Score: 5.92.

Total Rank: 6 – Laboratory Equipment – Mean Average Score: 5.93.

Less Important:

Total Rank: 7 – Small Class Size – Mean Average Score: 6.36.

Total Rank: 8 – Security – Mean Average Score: 6.49.

Total Rank: 9 – Social Activities – Mean Average Score: 7.09.

Least Important:

Total Rank: 10 – Sports – Mean Average Score: 7.74.

Total Rank: 11 – Industry Support – Mean Average Score: 8.17.

Total Rank: 12 – Cafeteria – Mean Average Score: 9.23.

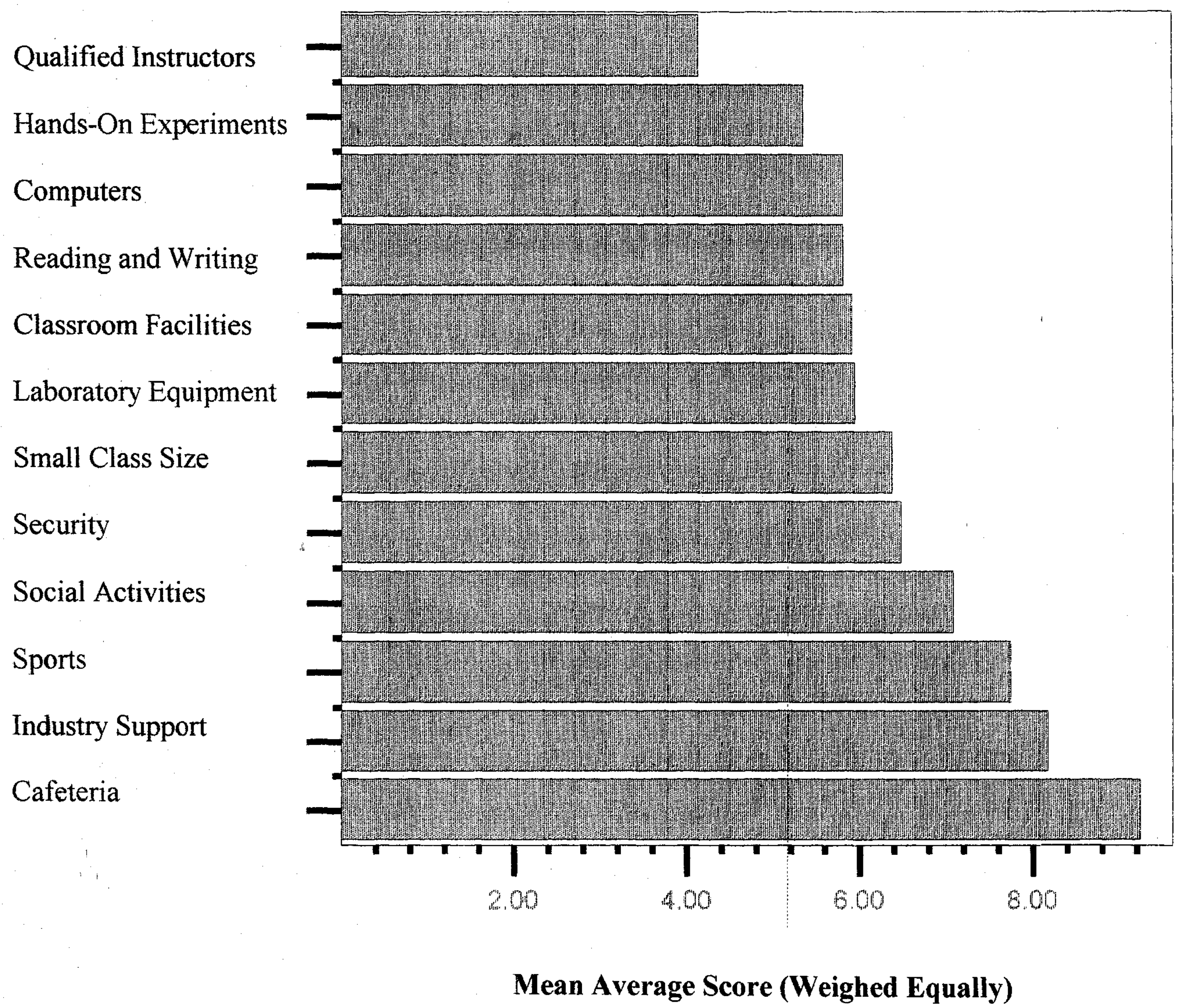

Figure 1. **Student and parent surveys.**

Items Ranked First by Students and Parents

The items ranked first most often by students and parents (weighed equally; see Table 2) were qualified instructors (percentage and rank, 30.5%, 1st) and security (15.2%, 2nd). Sports (11.3%, 3rd) and reading and writing (10.3%, 4th) were also ranked first most often.

Items that were in the middle when ranked first by students and parents were hands-on experiments (7.6%, 5th) and small class size (4.9%, 6th). Social activities (4.5%, 7th) and computers (4.4%, 8th) were also in the middle.

The items that were ranked first least often by students and parents were cafeteria (4.3%, 9th) and laboratory equipment (3.8%, 10th). Classroom facilities (2.2%, 11th) and industry support (1.0%, 12th) were also ranked first least often.

Table 2

Items Ranked First by Students and Parents

The items ranked first by students and parents (weighed equally) are as follows:

Most Often

Total Rank 1 – Qualified Instructors – 30.5% ranked as most important

Total Rank 2 – Security – 15.2% ranked as most important

Total Rank 3 – Sports – 11.3% ranked as most important

Total Rank 4 – Reading and Writing – 10.3% ranked as most important

Middle

Total Rank 5 – Hands-On Experiments – 7.6% ranked as most important

Total Rank 6 – Small Class Size – 4.9% ranked as most important

Total Rank 7 – Social Activities – 4.5% ranked as most important

Total Rank 8 – Computers – 4.4% ranked as most important

Least Often

Total Rank 9 – Cafeteria – 4.3% ranked as most important

Total Rank 10 – Laboratory Equipment – 3.8% ranked as most important

Total Rank 11 – Classroom Facilities – 2.2% ranked as most important

Total Rank 12 – Industry Support – 1.0% ranked as most important

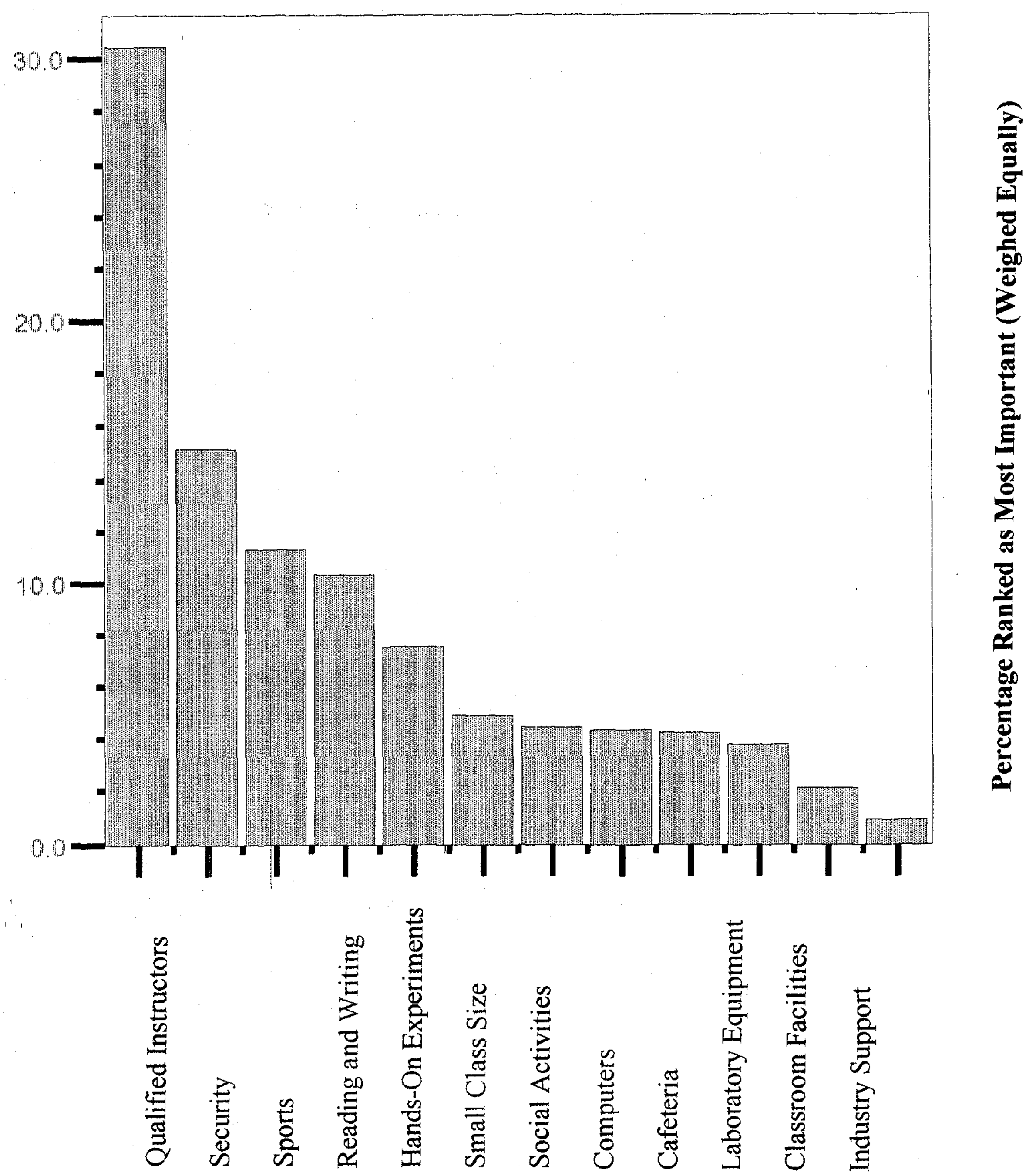

Figure 2. **Items ranked first by students and parents.**

Student Surveys

The items that 412 students (see Table 3) ranked as most important were qualified instructors (mean average score and rank, 5.16, 1st), hands-on experiments (5.44, 2nd), and computers (5.59, 3rd). Items that were also important to students were social activities (5.70, 4th), laboratory equipment (6.18, 5th), and classroom facilities (6.27, 6th).

Items that students ranked as less important were sports (6.40, 7th), security (6.50, 8th), and social activities (6.86, 9th). Items that were least important to students were small class size (7.02, 10th), industry support (8.19, 11th), and cafeteria (8.69, 12th).

Table 3

Student Surveys

The results of the 412 student surveys are as follows:

Most Important:

Student Rank: 1 – Qualified Instructors – Mean Average Score: 5.16.

Student Rank: 2 – Hands-On Experiments – Mean Average Score: 5.44.

Student Rank: 3 – Computers – Mean Average Score: 5.59.

Also Important:

Student Rank: 4 – Social Activities – Mean Average Score: 5.70.

Student Rank: 5 – Laboratory Equipment – Mean Average Score: 6.18.

Student Rank: 6 – Classroom Facilities – Mean Average Score: 6.27.

Less Important:

Student Rank: 7 – Sports – Mean Average Score: 6.40.

Student Rank: 8 – Security – Mean Average Score: 6.50.

Student Rank: 9 – Reading and Writing – Mean Average Score: 6.86.

Least Important:

Student Rank: 10 – Small Class Size – Mean Average Score: 7.02.

Student Rank: 11 – Industry Support – Mean Average Score: 8.19.

Student Rank: 12 – Cafeteria – Mean Average Score: 8.69.

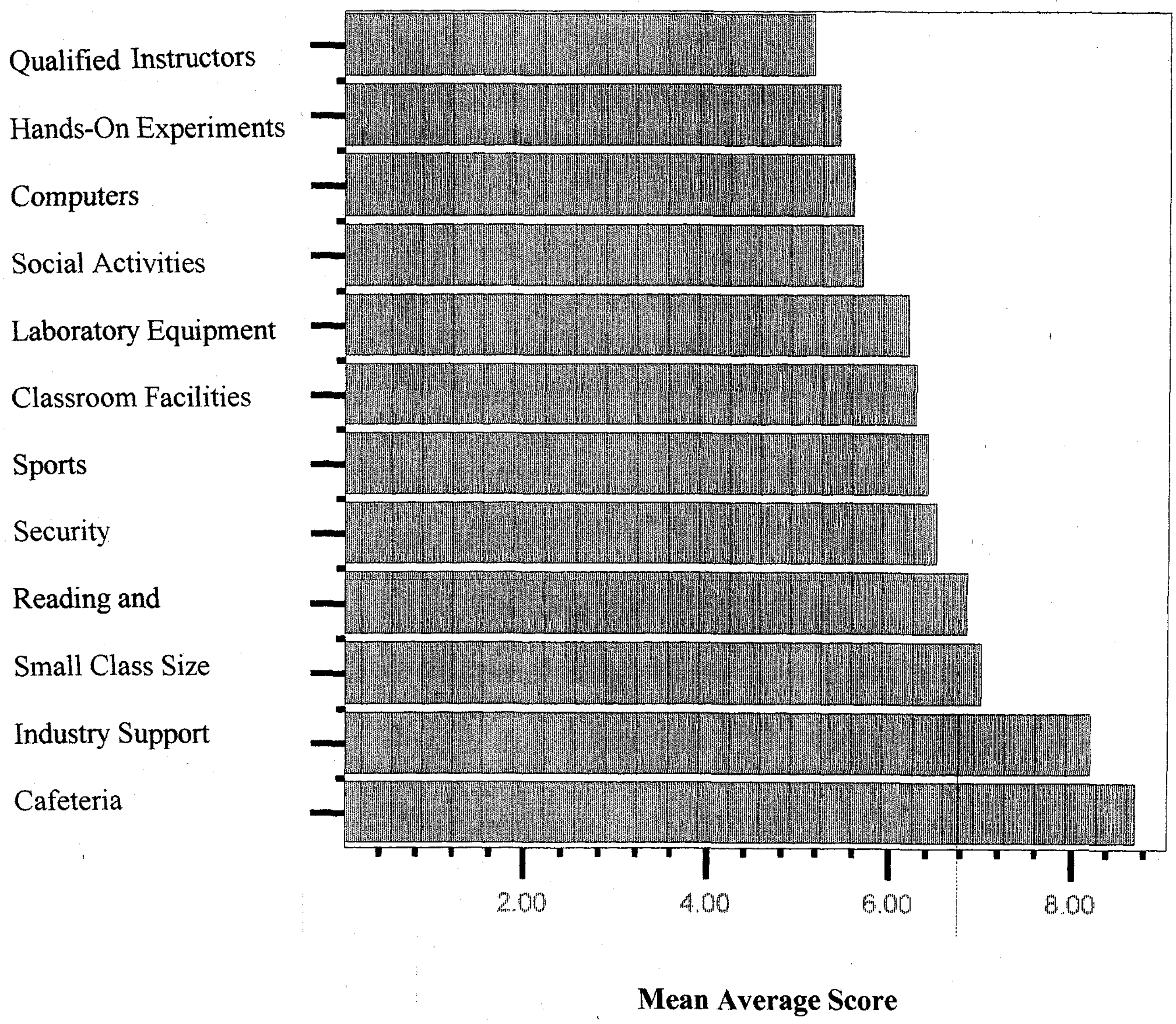

Figure 3. **Student surveys.**

Items Ranked First by Students

The items ranked first most often by students (see Table 5) were sports (percentage and rank, 19.7%, 1st) and qualified instructors (18.9%, 2nd). Security (13.1%, 3rd) and hands-on experiments (10.3%, 4th) were also ranked first most often.

Items that were in the middle when ranked first by students were reading and writing (8.5%, 5th) and social activities (8.3%, 6th). Laboratory equipment (5.6%, 7th) and computers (5.1%, 8th) were also in the middle.

The items that were ranked first least often by students and parents were small class size (4.1%, 9th) and classroom facilities (3.4%, 10th). Cafeteria (3.2%, 11th) and industry support (1.0%, 12th) were also ranked first least often.

Table 4

Items Ranked First by Students

Most Often

Student Rank 1 – Sports – 19.7% ranked as most important

Student Rank 2 – Qualified Instructors – 18.9% ranked as most important

Student Rank 3 – Security – 13.1% ranked as most important

Student Rank 4 – Hands-On Experiments – 9.2% ranked as most important

Middle

Student Rank 5 – Reading and Writing – 8.5% ranked as most important

Student Rank 6 – Social Activities – 8.3% ranked as most important

Student Rank 7 – Laboratory Equipment – 5.6% ranked as most important

Student Rank 8 – Computers – 5.1% ranked as most important

Least Often

Student Rank 9 – Small Class Size – 4.1% ranked as most important

Student Rank 10 – Classroom Facilities – 3.4% ranked as most important

Student Rank 11 – Cafeteria – 3.2% ranked as most important

Student Rank 12 – Industry Support – 1.0% ranked as most important

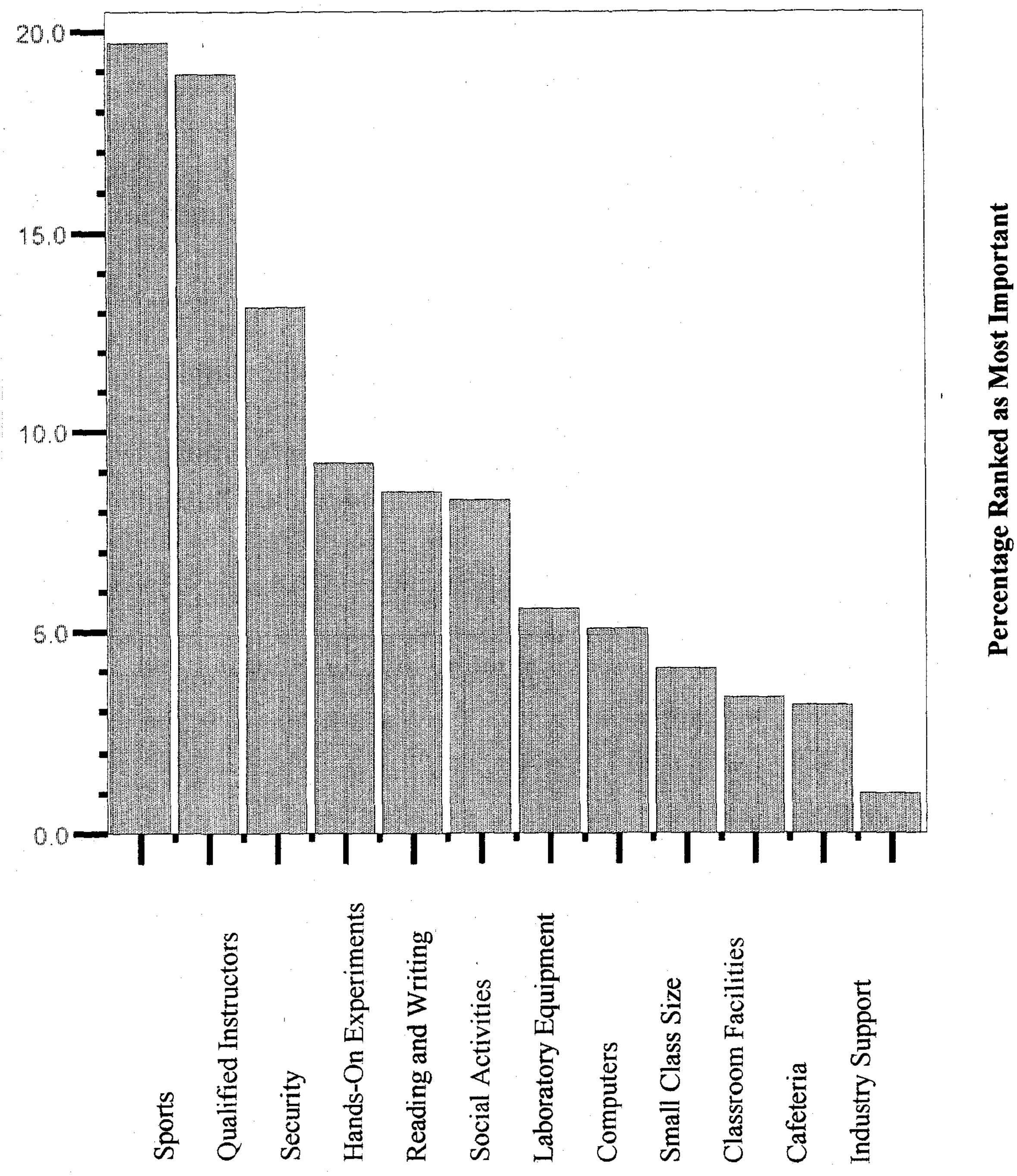

Figure 4. **Items ranked first by students.**

Parent Surveys

The items that 218 parents (see Table 4) ranked as most important were qualified instructors (mean average score and rank, 3.12, 1st), reading and writing (4.78, 2nd), and hands-on experiments (5.24, 3rd). Items that were also important to parents were classroom facilities (5.57, 4th), laboratory equipment (5.67, 5th), and small class size (5.70, 6th).

Items that parents ranked as less important were computers (6.00, 7th), security (6.47, 8th), and industry support (8.14, 9th). Items that were least important to parents were social activities (8.47, 10th), sports (9.07, 11th), and cafeteria (9.77, 12th).

Table 5

Parent Surveys

The results of the 218 parent surveys are as follows:

Most Important:

Parent Rank: 1 – Qualified Instructors – Mean Average Score: 3.12.

Parent Rank: 2 – Reading and Writing – Mean Average Score: 4.78.

Parent Rank: 3 – Hands-On Experiments – Mean Average Score: 5.24.

Also Important:

Parent Rank: 4 – Classroom Facilities – Mean Average Score: 5.57.

Parent Rank: 5 – Laboratory Equipment – Mean Average Score: 5.67.

Parent Rank: 6 – Small Class Size – Mean Average Score: 5.70.

Less Important:

Parent Rank: 7 – Computers – Mean Average Score: 6.00.

Parent Rank: 8 – Security – Mean Average Score: 6.47.

Parent Rank: 9 – Industry Support – Mean Average Score: 8.14.

Least Important:

Parent Rank: 10 – Social Activities – Mean Average Score: 8.47.

Parent Rank: 11 – Sports – Mean Average Score: 9.07.

Parent Rank: 12 – Cafeteria – Mean Average Score: 9.77.

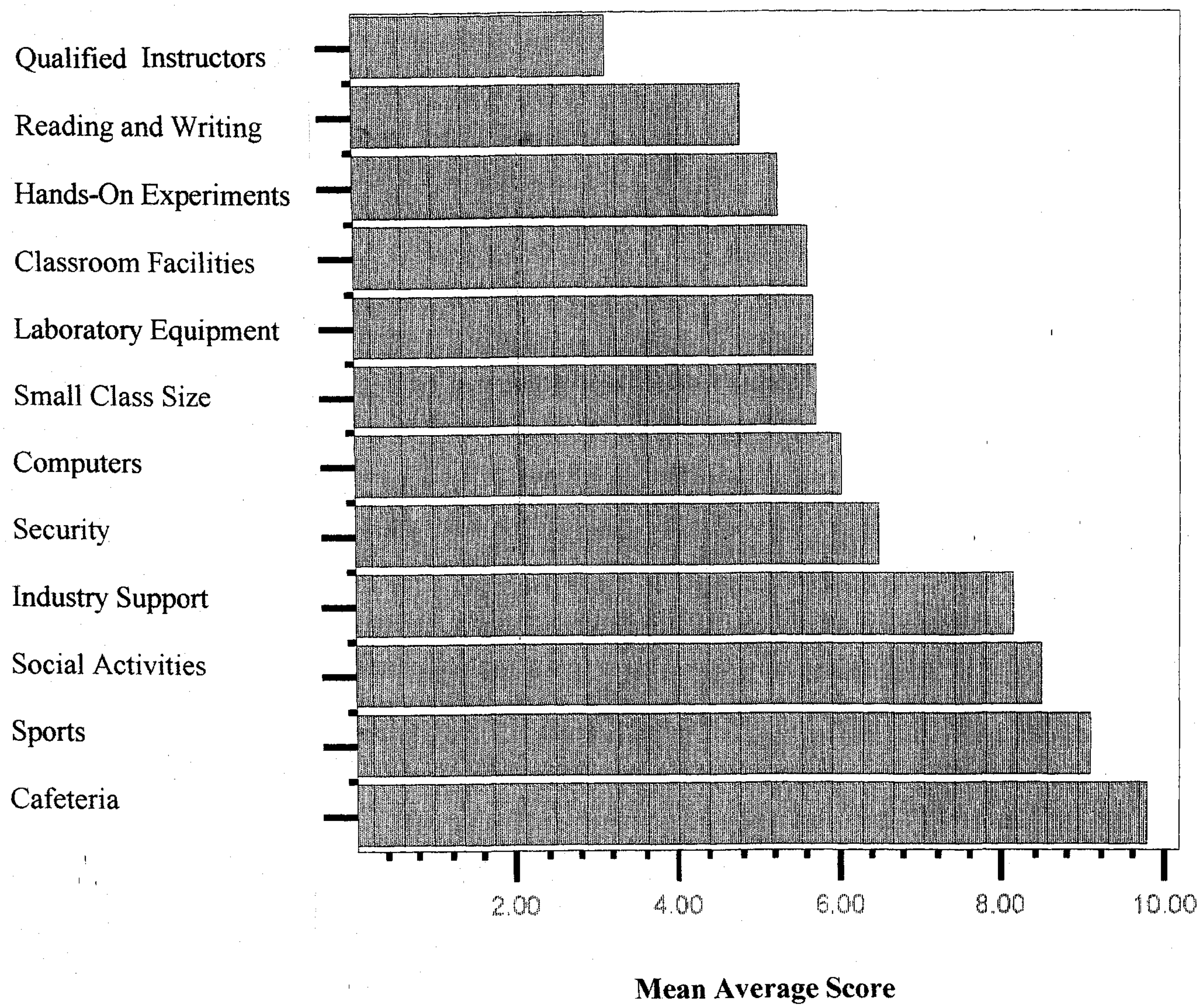

***Figure* 5. Parent surveys.**

Items Ranked First by Parents

The items ranked first most often by parents (see Table 6) were qualified instructors (percentage and rank, 42.7%, 1st) and security (17.9%, 2nd). Reading and writing (12.4%, 3rd) and hands-on experiments (6.4%, 4th) were also ranked first most often.

Items that were in the middle when ranked first by parents were small class size (6.0%, tied for 5th) and cafeteria (6.0%, tied for 5th). Computers (4.1%, 7th) and sports (3.2%, 8th) were also in the middle.

The items that were ranked first least often by parents were laboratory equipment (2.3%, 9th) and industry support (1.4%, tied for 10th). Classroom facilities (1.4%, tied for 10th) and social activities (0.9%, 12th) were also ranked first least often.

Table 6

Items Ranked First by Parents

Most Often

Parent Rank 1 – Qualified Instructors – 42.7% ranked as most important

Parent Rank 2 – Security – 17.9% ranked as most important

Parent Rank 3 – Reading and Writing – 12.4% ranked as most important

Parent Rank 4 – Hands-On Experiments – 6.4% ranked as most important

Middle

Parent Rank 5 (tie) – Small Class Size – 6.0% ranked as most important

Parent Rank 5 (tie) – Cafeteria – 6.0% ranked as most important

Parent Rank 7 – Computers – 4.1% ranked as most important

Parent Rank 8 – Sports – 3.2% ranked as most important

Least Often

Parent Rank 9 – Laboratory Equipment – 2.3% ranked as most important

Parent Rank 10 (tie) – Industry Support – 1.4% ranked as most important

Parent Rank 10 (tie) – Classroom Facilities – 1.4% ranked as most important

Parent Rank 12 – Social Activities – 0.9% ranked as most important

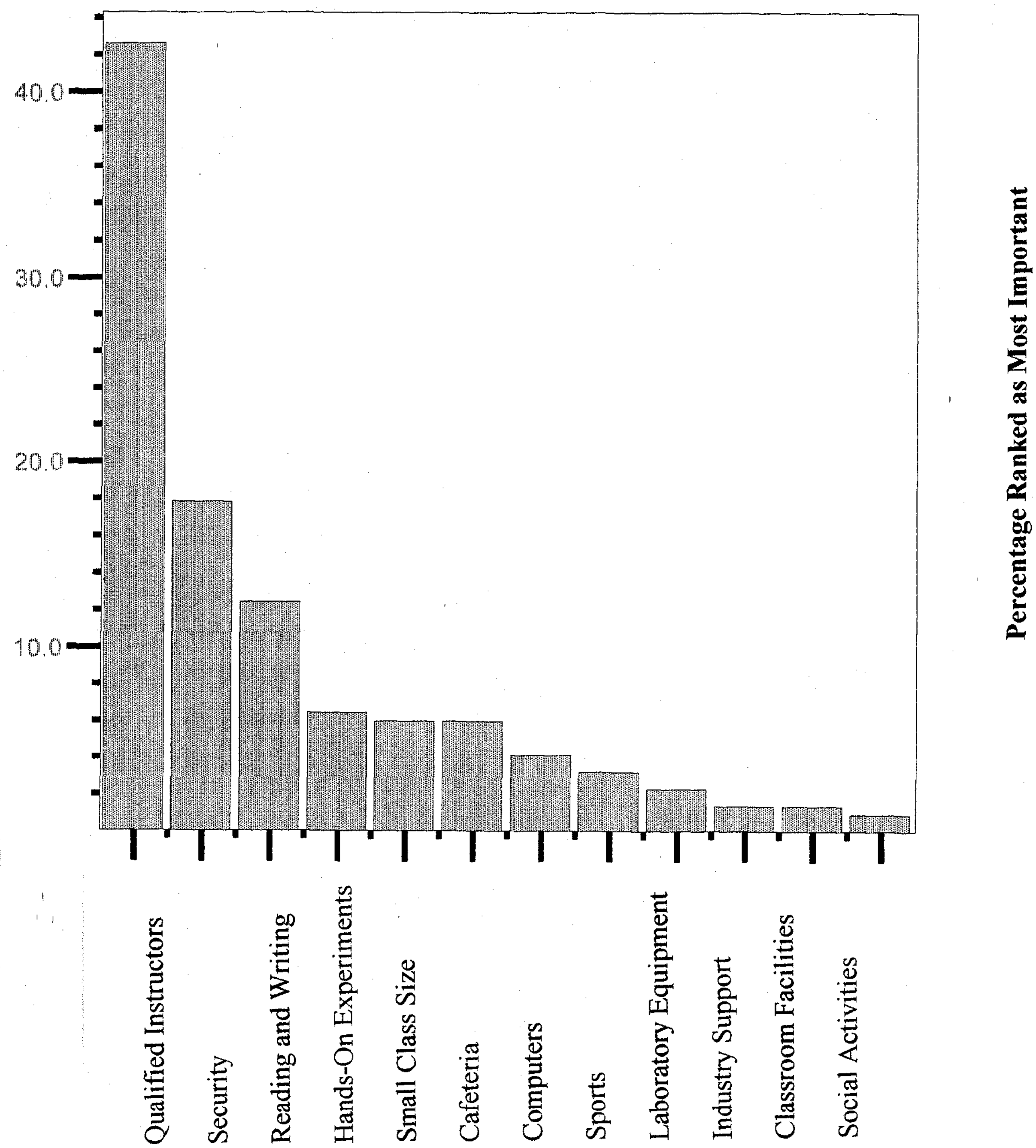

Figure 6. **Items ranked first by parents.**

T-Tests for Variables Important to Provide Quality Science Instruction

When t-tests (see Table 7) were conducted to compare the student and parent item rankings, the differences were found to be significant as follows: For qualified instructors, students (mean average score, standard deviation, and number of cases; 5.16, 3.55, 412) and parents (3.12, 2.83, 218), the t-score was 7.84 and the alpha level was .001*** (*** indicates the alpha level (p) was $\leq$ .001). For hands-on experiments, students (5.44, 3.04, 412) and parents (5.24, 2.96, 218), the t-score was .796 and the alpha level was .427. For computers, students (5.59, 2.85, 412) and parents (5.99, 2.36, 218), the t-score was 1.90 and the alpha level was .059.

For reading and writing, students (6.86, 3.52, 412) and parents (4.78, 2.83, 218), the t-score was 8.03 and the alpha level was .001***. For classroom facilities, students (6.26, 3.02, 412) and parents (5.57, 2.64, 218), the t-score was 2.99 and the alpha level was .003** (** indicates $p \leq .01$). For laboratory equipment, students (6.18, 2.90, 412) and parents (5.67, 2.74, 218), the t-score was 2.15 and the alpha level was .032* (* indicates $p \leq .05$).

For small class size, students (7.02, 3.36, 412) and parents (5.70, 3.23, 218), the t-score was 4.75 and the alpha level was .001***. For security, students (6.50, 3.75, 412) and parents (6.47, 3.89, 218), the t-score was .079 and the alpha level was .937. For social activities, students (5.70, 3.10, 412) and parents (8.47, 2.70, 218), the t-score was 11.59 and the alpha level was .001***.

For sports, students (6.41, 4.19, 412) and parents (9.07, 2.99, 218), the t-score was 9.22 and the alpha level was .001***. For industry support, students (8.19, 2.65, 412) and parents (8.14, 2.56, 218), the t-score was .204 and the alpha level was .839. For cafeteria, students (8.69, 3.35, 412) and parents (9.77, 2.82, 218), the t-score was 4.26 and the alpha level was .001***.

Table 7

T-Tests for Variables Important to Provide Quality Science Instruction

	Students			Parents				
	M	SD	N	M	SD	N	t	p
Qualified Instructors	5.16	3.55	412	3.12	2.83	218	7.84	.001***
Hands-On Experiments	5.44	3.04	412	5.24	2.96	218	.796	.427
Computers	5.59	2.85	412	5.99	2.36	218	1.90	.059
Reading and Writing	6.86	3.52	412	4.78	2.83	218	8.03	.001***
Classroom Facilities	6.26	3.02	412	5.57	2.64	218	2.99	.003**
Laboratory Equipment	6.18	2.90	412	5.67	2.74	218	2.15	.032*

Note. *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$. (table continues)

Table 7 (Continued)

T-Tests for Variables Important to Provide Quality Science Instruction

	Students			Parents				
	M	SD	N	M	SD	N	t	p
Small Class Size	7.02	3.36	412	5.70	3.23	218	4.75	.001***
Security	6.50	3.75	412	6.47	3.89	218	.079	.937
Social Activities	5.70	3.10	412	8.47	2.70	218	11.59	.001***
Sports	6.41	4.19	412	9.07	2.99	218	9.22	.001***
Industry Support	8.19	2.65	412	8.14	2.56	218	.204	.839
Cafeteria	8.69	3.35	412	9.77	2.82	218	4.26	.001***

Note. *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$.

Interviews and Focus Groups Outcomes

Ten experts participated in interviews and focus groups. An astronomer, a biologist, a chemist, a geologist, a physician, a physicist, and a psychologist, participated in interviews. A cosmetologist, a nutritionist, and a zoologist participated in a focus group. It was intended that the experts would form a spectrum of science including scientists in pure forms such as biologist, chemist, and physicist, as well as some of science's more accessible manifestations such as physician, nutritionist, and cosmetologist.

Ten educators participated in interviews and focus groups. A mentor teacher, a principal, and a school board member participated in interviews. A biology teacher, a life science teacher, a physical science teacher, a physics teacher, an anatomy and physiology teacher, a special education teacher, and a teacher's aide, participated in focus groups.

The participants in the focus groups and the interviews were asked to discuss their responses to questions that relate to science education in general, as well as the survey topics. Participation in an interview or a focus group format was determined by practical considerations relating to the needs of the participants.

Qualified Instructors

A characteristic of excellent education in general, and outstanding science education in particular is qualified instructors. The educators who participated in focus groups and interviews shared their views on this topic. According to a school board member, an instructor should be a people person.

> You have to like students; you have to connect. Some teachers turn their back and teach themselves a wonderful lesson. Teachers learn from every class. Teachers should receive ongoing training, growth, stimulation,

> mentoring, interaction with peers, and peer review. They should know that teachers are respected; money goes hand-in-hand with respect; $36,000 for a starting teacher will attract good ones. Administrators need to show respect to the teachers, and teachers need to show respect to the students. What's wrong with a 65-year-old beginning teacher? Schools should work with industry to bring 55-year-old retirees into teaching.

According to a principal, "At the elementary level it would be wonderful if you could provide science specialists. The regular education teacher focuses on the area that they're comfortable with." If you have groups or blocks, you have an advantage. Specialists are common in the East and in the Midwest. She said, "Schools should offer comparable pay for the area, however, you get into problems if you start paying more for science teachers over regular education teachers." Maybe districts will start looking at giving credit for more than 5 years experience. "I'm not sure if colleges are preparing teachers. What I hear from teachers is that they need more practical experience," she said. "Colleges should allow teachers to major in education, to do fieldwork undergraduate, to find out early if you like it and if you're going to be good at it," she added.

The principal commented that teachers who have come in from second careers have had age experience and have done a wonderful job; some new teachers have been naturals; some instructional aides, because they have had the experience working with children, have had an advantage. Practical knowledge, being able to relate everyday life types of experiences, connecting to previous learning, and emotional attachment, makes it more real and alive for children. "The more hands-on, going to places, the more they're going to remember, the more it's going to make sense," she noted.

A mentor teacher said, “I want someone that’s had the course work for teaching biology, for example.”

> I don’t want someone teaching biology who is trained for teaching earth science or political science. Just staying one day ahead of the students doesn’t work; you have to have a full background in the area. In elementary school, a science teacher needs to have a science background

The mentor teacher noted that incentives should be a clean, happy, safe work environment, with decent, competitive wages, with a staff that will help and back the teacher. If teachers are not supported, they will leave to another profession. Teachers’ wages are not what they should be compared to other professions. When teachers are happy, children learn. An industrial background in technology, engineering, chemistry, mining, pharmaceuticals, or machinery would be very important for science.

According to a biology teacher, teachers need to have a minimum of a Bachelor of Science in what they’re going to teach. To teach in high school, a specialized degree is needed. A student learning to be a teacher should shadow a good science teacher. A school could provide a good laboratory to show support, and an attractive classroom to teach real science. A special education teacher said that in California it is a problem teaching science in the elementary schools because teachers there have liberal arts degrees. “Teachers who have emergency certificates are unqualified. Stipends and bonuses would attract quality science teachers,” she said.

A life science teacher stated that instructors should have a bachelor’s degree in the area that they’re teaching. Teachers need the support of the administration and parents. “People come from industry, and then they have to go through the hassles, and it makes them want to leave the profession," he said. A better mentor program would help; 50% of teachers leave within the first 2 years. He asked, "How can you stay in a position where you have classes thrust at you that you don't want to teach, a position that you weren't hired for?" He said, "We got into this profession because we could explain things well. It's a gift." He added, "With experience you can be more spontaneous, and you learn more about your topic each year. You can't read a book to learn how to walk on a tightrope." Students love to hear personal stories. They want to know real world examples.

Teaching experience is important, said an anatomy and physiology teacher, and also a concentrated background in whatever discipline you're going to teach; it's going to show in your lessons, especially in the laboratories, if a teacher has the qualifications to make it meaningful. A teacher needs to know how to teach, to be able to transfer knowledge to students. He said, "Experience in industry would enable a teacher to bring it back to the classroom; they could talk about how you'll do it, and they could orient students towards careers." It's extremely hard to get somebody to teach chemistry or physics. "Experience is helpful," stated a teacher's aide, "but many people would consider that you might as well be a doctor or a nurse and get paid more."

A physics teacher commented that colleges could provide experience in the classroom prior to getting a job. Students learning to be teachers need to have more time spent in an internship. "You also need practical experience. How many teachers have sailed a sailboat?" he asked. An interesting lesson is to have a highway patrol officer brake a car at 60 M.P.H., and then the students can measure the skid. "You do have to talk about money. The people I go to school with are making six figures, and I'm not," he said. He added, "Burn out requires a separate support system. If you teach the same course, year after year, you have a drop off of enthusiasm." Students will listen if they know that their question is going to be answered.

According to a physical science teacher, having a teaching credential just says you're a good test-taker. The majority of your teachers' classes should be practical. She said, "I've learned the most by going to other teachers' classes." To retain teachers, treat them with respect. A job description, a true picture, would help. They should receive credit for practical knowledge. She said, "With experience, you know what questions they're going to ask." Teachers need to come up with many examples through personal experience. "You can ask students about the science that they saw on 'ER,' or the science related to their dirt bike," she said. A teacher with experience can lead students to potential careers.

In summary, the educators who participated in focus groups and interviews believed that instructors should be people persons, able to connect with students. Science specialists would be desirable at the elementary level to attain confidence and knowledge of the subject. A background in technology, engineering, laboratory, or another application of science would be very useful.

The experts who participated in interviews and focus groups also shared their views regarding quality instructors. According to a geologist, what is most important to science education is a competent instructor. They should be trained in science, and trained in the field in which they teach. A physicist noted that it is most important to have teachers that inspire students. "I remember teachers who inspired my imagination," he said.

A biologist said that science instructors should be extremely knowledgeable. Their education and experience should be concentrated in the field that they are teaching. In the classroom, stated a chemist, teachers should go over the theories and laws, give the students problems, and give them time to practice their solutions. There should be questions and lots of interaction between the students and the teacher.

A psychologist commented that science teachers should have a good science and educational background. An engineer that goes on to teaching would be good. Experience should be acknowledged. Additional incentives for science would encourage them to become a teacher. Bringing experience into the classroom, explaining things from a practical standpoint, would benefit students.

According to a physician, life experience is paramount. He said, "My brother went back to teaching when he was 51 years old; he had a lot of life to draw back on. My physics teacher was retired from General Dynamics; he taught what he used to do." Two teachers in a classroom should be achieved by combining classes. Money should be used to attract teachers.

> In the real world, I'm good at what I do. I develop relationships. My business sense has to be good. In the corporate world, they attract the best minds because they are reimbursed, and if they don't perform to the standards, they are told to go do something else. So pay more money, do away with tenure, and go for it. Make it more competitive with better rewards.

The physician commented that life experience to draw on is vital. He said, "A teacher has to learn how to teach. Life experience will help you to get good working with people."

> It would be great to have a retired Fish and Game warden as your biology teacher or as your botany teacher, or a person who worked for the Jet Propulsion Laboratory as your physics teacher or your math teacher. Science is better taught by example; you have to have living life examples, and you have to be good at it to teach.

A zoologist commented that teachers need to know the material, they should not be guessing, they have to have a strong focus on science. He said, "If you don't have experience, you have nothing. If you haven't done it, you don't have the knowledge more than the students, basically." A cosmetologist said that teachers need specialized training, but not necessarily a degree. "If you give teachers small class sizes and decent pay, you'll keep them around longer. Experience is important so that the teachers are able to teach," she said. According to a nutritionist, "You can't teach science at home, unlike nouns, which is why science teachers should be paid more." Teacher experience is important so that the kids learn the things they will need to know to progress in life.

In summary, the experts who participated in interviews and focus groups felt that instructors should attain competence through training as scientists and as teachers. Instructors should be experienced and knowledgeable in the fields they teach. Science teachers should be able to inspire students.

In conclusion, the experts and the educators agreed on the importance of knowledge of science to achieve quality instruction. They also agreed that experience in the real world would be beneficial. The experts and the educators identified interpersonal skills as necessary for quality instruction.

Hands-On Experiments

In addition to qualified instructors, another characteristic of excellent education in general, and outstanding science education in particular is hands-on experiments. The educators who participated in focus groups and interviews shared their views on this topic. According to a school board member, students should be doing hands-on experiments all of the time. Hands-on can be computer-on. He said, "They should work with pulleys, ratios, wind, mass, density, and volume. They can memorize the math tables, but will they be able to think? It takes in the kinetic, the visual, and the auditory." Hands-on experiments stimulate. Cooking can be a hands-on experiment.

Hands-on experiments, stated a mentor teacher, should be done whenever possible. "The more experiments you have, the better you are," he said. If possible, there should be a hands-on experiment with every lesson. He said, "The more hands-on, the more they'll retain. I still remember my chemistry experiments from 40 years ago." He added, "You need to cut a frog, you need to build a structure and put a weight on it, you need to test rocks, and you need to do carbon dating."

According to a biology teacher, science students should perform hands-on experiments as often as possible. "You're more likely to remember the lesson when you do it hands-on," he said. An anatomy and physiology teacher noted that hands-on experiments should be done every fifth day. Students should be using microscopes.

> If you're going to be a veterinarian, or a surgeon, you're going to have to have real practice. You're not going to learn about the surprising things unless you try it, because something will always be a little bit different than it is in theory.

The biology teacher said that hands-on experiments develop a deeper understanding. When students do something hands-on, it means more, and they remember it. According to a special education teacher, hands-on experiments are especially important for the tactile learners. Students should be working hands-on with genetic strands, pulleys, and minerals. They should experience the feel of concrete and the smell of sulfur.

A physical science teacher said that ideally, students should be doing hands-on experiments every day, because for some kids, that is the only way they are going to learn. Measurements using the metric system are excellent hands-on experiments that students should perform. According to a life science teacher, hands-on experiments engage multiple modalities. She said, "Hands-on are not fluff; students manipulate the materials on their own, demonstrate their own understanding." Students could be manipulating models of the atom. Hands-on involves their senses of smell, touch, and taste. According to a physics teacher, some people have to do something to understand it. Students can drop a ball, then measure the distance of the drop, the time it takes to hit the floor, and the height of the bounce.

In summary, the educators who participated in interviews and focus groups believed that hands-on experiments should be performed daily, with every lesson. For some students hands-on is necessary for thinking and understanding. Hands-on experiments are important, memorable lessons.

The experts who participated in interviews and focus groups also shared their views regarding hands-on experiments. Science education, according to a biologist, should be stressing an inquiry, hands-on approach. Students should be performing problem solving. "They should be thinking about how people have done science in the past. They should be figuring things out for themselves, rather than the instructor telling them what it is," she said.

The biologist stated that students need opportunities to work with hands-on materials and ideas. Hands-on experiments or lectures could be inquiry.

> It is practically impossible to learn science without laboratories. Laboratories are expensive, but trying to teach science without them is like trying to teach art without paint and clay. Without laboratories, students would be missing most of the basics. They would be missing why science is fun and important. Science should not be presented as here's what we know, it should be more of a process. Science is a way of thinking about the world. It makes more sense when students have the evidence behind why things work the way they do.

A chemist stated, "What is important in science education is to select a problem from the real world, to apply scientific analysis, and to develop solutions that haven't been thought of before." From elementary through middle school, students should get to see the value of science through interesting things. They should start to use deductive reasoning. They could study how day-to-day phenomena can be explained and managed, understood and predicted, and possibly not controlled. They could be asked, "How does weather occur?" From middle school through high school, the focus should be on the empowering nature of science. Building from the groundwork laid in their prior school years, they could get more into understanding and using their knowledge to solve problems. They could be asked, "How does a refrigerator work, and how could you develop a better one?"

The chemist said that science students should learn the fundamentals of the things that we have discovered. Science education should stress application.

> To create the technology that is desired today, today's scientists need to understand the fundamentals of how things work, which is based upon theories and laws. The examples and problems should be from the real world, something that students can relate to.

"The most important thing for science education," according to the chemist, "is to stimulate interest in science." K-12 science students should learn how to observe nature. High school students should be gathering data, thinking critically, solving problems, and acquiring general science knowledge.

The chemist commented that interest in science is stimulated in laboratories. He said, "The more that students participate in hands-on laboratories, the better. Unfortunately, the trend is to cut back." In laboratories, students should collect data, perform critical thinking, and do problem solving. They can do case studies.

A geologist commented that the resources, technology, and other materials to perform hands-on experiments are very important to science education. The facilities should include a separate laboratory. A school that supports science would have a good library with access to the books, literature, and journals that are critical to science education.

The geologist said, "In science education it is important to understand the process of posing questions about things that we don't understand."

> To answer questions, science organizes information according to logic and rules. Explanations of the world around us are built from facts and details. In lectures, larger questions are answered by working out the solutions to smaller questions. In laboratories students are allowed to work out their strategies, to design or conduct investigations. Students could look at a geologic model of the Earth and investigate the sequence of events that created it. They could work with samples

> such as rocks and minerals and test them to find groupings according to simple rules such as hardness, streak, and luster. Students could go on a field trip to the beach where they could identify sand patterns and measure the speeds of streams of water.

"Teaching logic is most important," stated the geologist, "no matter what the field of science, the scientific method is important." Students should make observations, to prove or disprove their hypotheses. They should be reasoning. There should be demonstrations and science experiments so that students see what those mean. Students should form their own ideas of why they are seeing what they are seeing.

According to the geologist, students should engage in hands-on activities. They could put a boat on water, blow on it, and see that it moves. Or it could be deductive; students could be asked how they would make the boat move.

According to an astronomer, "Facts are a bad way to teach. The process of science is important." He said, "Science is an ongoing process. Students should be aware of the discovery of science." Effective ways to teach provide processes over facts. Tests are measuring knowledge, not understanding.

The astronomer described how experts think: processing, clumping, forming systems and hierarchies of information, picking and choosing what applies. When kids think, they do not remember disassociated facts; they need something to hang information onto.

The astronomer also commented that students should appreciate and enjoy science through projects such as designing robots, things that are new and interesting. Engineering can be presented in K-12. Instead of learning abstractly about simple machines or mathematics, students could apply their knowledge by building robots with gears. That is hands-on inquiry; the robot may or may not work. They have the thrill of putting it together and testing it. In K-6 students can build towers with straws and paper. In the middle grades they could build simple robots that they can use to explore landscapes. In high school they can build robots that could compete to destroy each other.

A physicist commented that having a strong mathematics background is important to understanding science. He said, "Mathematics is the language of science." Using problem solving or experiments should develop patience and perseverance. "Students want sound bites, simple one-stop problems, they demand immediate answers; in real science you can't always do that," he said. Technology is based in science. He added, "If you want gadgets, you need to develop them from a foundation of scientific knowledge. Practically everything includes science." Students need to be able to show where a result comes from. Science students need to be able to apply mathematics to solve a problem. They need to be able to perform math mechanically, and to understand abstract mathematics. In a laboratory they can collect data, perform calculations, derive statistics, understand the limitations of precision, and create meaningful analysis. Students should develop awareness by spending time talking about science applications and their underlying principles.

The physicist posited, "What ignites, what excites students in science is research." They develop understanding and a new purpose for themselves beyond just getting into a good university. This can be duplicated at the high school and elementary level. "Some students have been conditioned to being told how it is; when they do research they learn more because they become participants," he said.

According to the physicist, good students sometimes flounder in college; they are without motivation. Getting science students involved in research projects develops motivation.

A psychologist said, "You need to see it and hear it and feel it. Hands-on helps the students to fully understand what's going on." Hands-on experiments should be performed several times per week. "When you're doing an experiment hands-on, you are more involved, and you have more ownership of the learning," she said. Using microscopes and dissecting are good hands-on experiments. Hands-on helps to build concepts.

A physician stated that students should constantly be performing hands-on experiments.

> With hands-on, you remember what you did, and you can relate with it. When you do a hands-on experiment, you notice if the materials make a sound or a smell. Hands-on experiments should be anything that would make students think, like an explosion.

A nutritionist stated that students should do hands-on experiments at least once a week. She said, "Students could do a dissection of the heart of a reptile or a cat, but not a human." Students should do astronomy. According to a cosmetologist, "Science is better when you do hands-on experiments." A zoologist posited, "Like a doctor doing a surgery, you need to see it to learn how to do it." They should experiment with chemicals.

In summary, the experts who participated in interviews and focus groups felt that students should be using hands-on experiments to perform inquiry, to problem solve, to figure things out for themselves. They felt that science is practically impossible to teach without laboratories. The participants believed that science makes more sense when students attain the evidence behind the facts by utilizing hands-on materials.

In conclusion, educators noted that hands-on lessons are the most memorable. The experts and the educators agreed that hands-on experiments are critical to understanding. They agreed that all lessons should include hands-on activity. Experts valued the experience of students' figuring things out for themselves.

Computers

In addition to hands-on experiments, another characteristic of excellent education in general, and outstanding science education in particular is computers. The educators who participated in focus groups and interviews shared their views on this topic. A school board member noted that the students are computer literate. He said, "There are so many experiments that can be done on the computer, and they are less dangerous and less expensive." Each classroom should have 24 computers, one for each student, and laptops for students of a certain age to go home and to school. Students should use "Power Point" presentations. There should be good printers in the classroom, probably at a student/printer ratio of 3 to 1, or 4 to 1. An "Outlook" or a "Palm Pilot" could be issued to each responsible student. Students should have video games on their computers.

Computers, stated a principal, should be used for researching topics and information. Students should also use computers for putting reports and projects together. Laptop and desktop computers are needed. Six computers per classroom would be great, and also a computer laboratory. Every teacher could have a laptop, and they could be checked out to students. Teachers could project a computer image onto a large screen to share useful resources with their classes, like information from sites on the Internet.

A mentor teacher stated that there should be a computer for every two students. They should use the Internet to search for information. They should have new equipment and software. There should be enough computers for hands-on learning. They need plotters for every 10 or 12 stations.

A biology teacher noted that students should be able to research the Internet for reports. Their computers could have probe software for ph, light, and electronic measures. Schools should provide student-use computers for data management, graphing, and simulations. One computer to every two students would be best. According to an anatomy and physiology teacher, dissections could be done using computer software. He said, "You could have students do laboratories on the computer before they waste expensive materials." The ratio of computers to students should be 1 to 4. A special education teacher noted, "If you're doing research you're going to need a lot of computers, one computer for every student."

A physics teacher said that computers should be utilized in every way. They could be used to make presentations, or to search for information on the Internet. According to a life science teacher, a computer can be used as a tool, as a study guide, or to provide simulated work experience. There should be one computer per three students. The software for students needs to include a spreadsheet, a database, and a word processor. Students should be doing simulations, and they need to have text they can print. A physical science teacher noted, "You could identify Internet sites that you want students to access, and use buttons so they can't go past them. You can also set up an Intranet, so they can communicate with other students."

In summary, the educators who participated in interviews and focus groups felt that experiments such as dissections could be done effectively and efficiently on the computers. The participants believed that science topics could be researched and information could be found by using computers. There should be a computer for every two or three students.

The experts who participated in interviews and focus groups also shared their views regarding computers. According to a psychologist, science is dependent on computers. "Students who are skilled with computers are the ones who are going to be successful," she said. Each student should have a computer. They should have printers and scanners. Virtual reality would be very beneficial.

A physician stated, "Students should use computers constantly in the classroom. Their books should be on the computer. There should be one computer per kid. The Internet would give them access to resources. Every computer should have an Encarta Encyclopedia."

A nutritionist stated that there should be one computer for every five students, with a teacher to watch. The computers should have science software, like a diagram of the human body. Students should use word processors. A zoologist said that the school computers should not be for personal use. Each classroom should have an extra computer for the teacher. They should use spreadsheets and do graphing. According to a cosmetologist, a school should have one computer for every four students.

In summary, the experts who participated in interviews and focus groups felt that each student should have a computer. Students could use the Internet to access current information. Their future success will depend upon their computer skills, such as their ability to create meaningful charts and graphs.

In conclusion, the educators believed that computers could be used to perform experiments. The experts and the educators agreed that students should use computers to conduct research. Educators wanted one computer for every two or three students, while experts wanted each student to have his or her own. The experts felt that the development of computer skills is critical to future success.

Reading and Writing

In addition to computers, another characteristic of excellent education in general, and outstanding science education in particular is reading and writing. The educators who participated in focus groups and interviews shared their views on this topic. A school board member said that every day, whenever a laboratory experiment is done, the students should write it up. "Reading tests are designed for literature, we need to teach technical reading and writing. The tests don't reflect what the children are learning," he said. "Give them a technical manual and tell them to do it, like give them a manual on how to build a bicycle and then let them do it," he added.

According to a principal, reading and writing should be taught across the curriculum. For children who are interested in science, it would be a great way to get them to read. "It's a great way to tie into questions, natural curiosity, for example, my child would be interested in any book about snakes," she said. Reading and writing in science could include using graphs and charts, technical and informational reading, and creating tables and timelines.

According to a mentor teacher, scientists need to be able to read at a high grade level of fluency and understanding. They also need to express themselves in writing.

A biology teacher stated that schools should teach technical writing. Latin would also be good for science students to learn. An anatomy and physiology teacher said that students could do independent reading about topics in science. A scientist needs to be able to perform the mechanics of writing, and to understand English. A special education teacher said that they could study scientific vocabulary.

A life science teacher commented that a teacher could have students follow along while they read from a science text. Students need to write laboratory reports, and they need to be able to find scientific information. They need to be able to read technical articles, and they need to be able to decipher and to decode writings in science. They should write operational definitions of instructions. According to a physical science teacher, "You need to have a small class to teach reading and writing in science." A physics teacher noted that scientists need to know basic grammar. They need to be able to read and write procedural instructions.

In summary, the educators who participated in interviews and focus groups felt that students should write daily, such as writing up the results of their experiments. Some students would be motivated to read about high-interest subjects in science. They should learn technical writing.

The experts who participated in interviews and focus groups also shared their views regarding reading and writing. "Reading about science," said a physician, "is how I learned how to read. In the third grade, Popular Science and Cycle World magazines were exciting reading for me." When students want to know why something happened, teachers can guide them to find the answer by reading. Scientists need to read well enough to comprehend science articles, and they need to write well enough to relate their findings and ideas.

A psychologist said that science depends on the abilities to read and write. It is a subject that requires a lot of ability to communicate.

A zoologist commented that students do reading when they are learning science vocabulary. Science should be simplified for students who cannot read. A cosmetologist said that the students should use science dictionaries. A nutritionist stated that scientists need to know abbreviations and pronunciations.

In summary, the experts who participated in interviews and focus groups felt that in science students should learn to read for comprehension, and they should learn to write to express their findings and ideas. The participants believed that scientists require strong abilities to read, write, and communicate. Students should learn science vocabulary.

In conclusion, the educators felt that science students should be writing daily. They believed that technical writing should be taught. The educators and the experts agreed that students should do a lot of reading about science topics. The experts believed that scientists need strong abilities to read, write, and communicate. They felt that science vocabulary should be taught.

Classroom Facilities

In addition to reading and writing, another characteristic of excellent education in general, and outstanding science education in particular is classroom facilities. The educators who participated in focus groups and interviews shared their views on this topic. A school board member said, "A facility needs to be classy, to reflect your viewpoint, which is quality." Classrooms should have good lighting and good maintenance.

A principal said that the elementary school facilities are not set up for a laboratory. She said, "It would be great on every campus if you had a laboratory. You could take kids to a laboratory with everything stored there."

> A laboratory needs sinks and tables. A laboratory should have kits with all of the supplies kitted, like cotton balls and rubber bands. It should have microscopes, computer access to the Internet, and an overhead so you could model and everyone could see it.

A mentor teacher commented that "most junior high school classrooms don't have adequate laboratories; most districts won't support the expense." Blood test equipment, a wind tunnel, a computer program to design bridges or aircraft would be very important. Telescopes and rock-testing equipment would be desirable. He said, "I would want laboratories separate from lecture areas. I think there is more learning done if you have no more than one or two kids per laboratory, with enough sinks and scales so kids don't have to wait."

A teacher's aide commented that, "For classroom facilities, we have the basics. Our district didn't have anybody specify the requirements, so we got what we asked for." An anatomy and physiology teacher stated, “Science is so expensive that it takes years and years to get what we need. In six years we’re getting there, but it may be six to ten more years until we get what we need to be effective.” He added, “Classroom facilities for science should include a dual classroom, where you could do lecture in one room and have a laboratory in an adjacent location.” A special education teacher stated, “You need to have ongoing facilities repairs, and you need nice-sized sinks.” A biology teacher noted that a classroom should have a well laid-out floor plan where the students have unimpeded movement and the instructor has a view of the entire laboratory.

A physical science teacher stated, “You need all of the supplies to do all of the required laboratories.”

> You need tables. All of the science classrooms should be together. The classroom should have a low ceiling so that your voice projects. We can use the computers to do laboratories.

“Teachers need time,” stated a life science teacher, “and with standards there is less time.” He said, “We can do a lot with minimal things like paper clips and Popsicle sticks.” A physics teacher stated that the classrooms need to have storage. Some of the equipment needs to be enhanced.

In summary, the educators who participated in interviews and focus groups felt that science education facilities should be classy to reflect quality. The participants believed that elementary teachers should be able to bring students to well equipped, ready-to-go laboratories. Classrooms should be separate from laboratories.

The experts who participated in interviews and focus groups also shared their views regarding classroom facilities. Technology has taken over, stated a psychologist, and some schools are behind. More laboratory rooms are needed. She said, "You want a space for the laboratory, and another space for the classroom, because science has both the experiential and the academic work."

A physician said that classroom facilities are adequate at some schools. He said, "I think science is undertaught, we all get our awakening in college. Science is not taught in elementary; they need laboratories, from the fourth grade on. Kids have a basic scientific curiosity that we squelch in school."

A zoologist said, "Schools should not look like prisons." According to a cosmetologist, classrooms should have all the supplies to perform everything that is in the book, all of the experiments, at least. A nutritionist stated that there should be supplies for all the students.

In summary, the experts felt that the classrooms and the laboratories should be separate facilities. Elementary schools should have science laboratories. School facilities should create a positive atmosphere.

In conclusion, educators and experts agreed that classroom facilities should be high quality. They agreed that elementary schools should have science laboratories. Educators and experts agreed that the laboratories should be separate from the classrooms.

Laboratory Equipment

In addition to classroom facilities, another characteristic of excellent education in general, and outstanding science education in particular is laboratory equipment. The educators who participated in focus groups and interviews shared their views on this topic. According to a mentor teacher, "You need to have the physical equipment necessary to teach the state standards, and if you don't, just talking about it or reading about it in the book is not going to do the job properly." He added, "I think that schools would rather buy a maintenance truck than buy laboratory equipment."

A school board member said to look to industry to identify needs. There should be an obsolescence plan to replace a percentage each year. Buildings need to be dynamic and adaptable.

A biology teacher said, "For laboratory equipment, you need at least the bare minimum."

> You need an adequate sink, counter-top space, comfortable chairs, and telescopes. You have to have fire extinguishers and blankets. Science rooms should have heat detectors, not smoke detectors, to save from having unnecessary fire drills.

According to a teacher's aide, a laboratory should be equipped with a complete supply of glassware. A special education teacher stated that a laboratory has to have safety equipment, laboratory coats, and a first aid kit. Laboratories need better ventilation because chemical smells can go from room to room.

An anatomy and physiology teacher said that a laboratory could have an eyewash station, a bank of fume hoods, lockable storage, and lots of shelving. He said, "It would be great to have a computer at every laboratory station."

> If we had a start up budget for 2 to 10 years you could equip a school, and have an ongoing budget so as new technology comes along you could replace it. That's not how we do it; we open up new disciplines, and then later we get what we need.

According to a principal, laboratory equipment should include microscopes, televisions, database, spreadsheet, and word processing to record data. She said, "If you want to have children employable, the more you can make the laboratory like the real world, the better."

"If I had the money from textbooks," said a physics teacher, "I could buy good laboratory equipment, and I could buy one computer per student." According to a life science teacher, "We need to look ahead. As things keep developing, they're getting more expensive." The kids could make databases and web sites. A physical science teacher commented, "We need to have whatever equipment is out there."

In summary, the educators who participated in interviews and focus groups felt that laboratories should have all of the equipment necessary to teach the state standards. They felt that you need at least the bare minimum: sinks, countertops, and comfortable chairs. The participants believed that laboratories at schools should be like those in the real world.

The experts who participated in interviews and focus groups also shared their views regarding laboratory equipment. A physician commented, "There should be more chemicals and more bugs." The number one need is for an excited science teacher. A roving artist and a roving science teacher should be used in elementary schools.

According to a nutritionist, there should be nights when students and parents go together to do laboratories. The laboratory should have supplies to do experiments like frog dissections. A cosmetologist commented, "When students are performing experiments you need to have assistants." A zoologist stated, "In a laboratory you need to have all the safety devices."

In summary, the experts believed that science laboratories need more chemicals and supplies. They need to have more specimens for dissections. Safety devices are required.

In conclusion, educators believed that laboratories should have the equipment that is necessary to meet state standards. They felt that they need equipment to meet minimal academic and comfort requirements. Laboratories should be like the real world. Experts felt that laboratories need more supplies. Science laboratories need specimens for more dissections. They believed that safety devices are needed.

Small Class Size

In addition to laboratory equipment, another characteristic of excellent education in general, and outstanding science education in particular is small class size. The educators who participated in focus groups and interviews shared their views on this topic. "Ideally," commented a principal, "class size should be 15 or less, so they can do hands-on experimentation, in order for the teacher to monitor understanding."

> With a small class you can provide materials, and you can see if the experiment failures and provide feedback. With a large class, it's harder to find out if the children have a good understanding of the concepts.

"I believe," stated a school board member, "that class size should be 24 students or less, so that you better understand your students, how they learn, what they bring to class." Laboratory class should be 18 students. Learning, a feeling of camaraderie, and connection occurs when class size is small. Students understand where the teacher is going. Confrontation, chaos, and a hostile environment exist in a large class.

A mentor teacher stated, "Class size should be 24 to 30; in an hour class that would give you 2 minutes apiece for them. In a small class you can provide individual help, it's more manageable, and there are fewer interruptions," he said. "Also, in a small class you can have quality time with individual students, and you're not rushing all the time to get around to a large number of kids," he added. "In a large class, you spend more time policing the class, trying to keep order, and correcting the bad students, than you are teaching," he said.

According to a special education teacher, ideally class size should be 24 students. Small classes permit cooperating in learning and more monitoring to increase on-task activity. With a small class, a teacher can effectively utilize rubrics for the grading system. A teacher with a small class can implement different teaching strategies, can address learning styles of students, and can use methods to teach to the seven intelligences. Grading scores improve in a small class because of one-on-one attention and immediate feedback.

A biology teacher commented, "With a class size of 32 you can perform laboratories safely, but to teach effectively you should have 24." When class size is small retention is increased, and there are fewer disciplinary problems. Small class size allows for more one-on-one interaction, and more hands-on learning with limited equipment. Safety is achieved when class size is small, like when students are working with scalpels. "Small class size is especially important when you're grading students' essays and writings," he said. "With a large class you become less effective as a teacher because you're focusing on discipline problems," he added. "Students in a large class have less access to equipment, and if we don't have enough equipment we tend not to do that laboratory," he said.

An anatomy and physiology teacher stated that class size should be no more than 28 students.

> In a small class, the students are more focused, and there are fewer distractions. With a small class, no kids fall through the cracks, and a slight disability is discovered early. In a large class, high-level kids tend to be very social, so it's an issue to try to get them to focus. Safety is a concern with a large class; the more bodies you have in a room, the more likely it is that something is going to go bad.

A teacher's aide said that class size should not exceed 24. "When you have a large class, attendance can take 5 to 10 minutes," she said.

A physical science teacher commented, "When I have a small class, questions are answered. I'm available to walk around and answer questions. When the class size is large, your job is all classroom management, and there's less teaching and learning." A physics teacher said that a small class size allows the quieter students to interact with the teacher. A large class has to be more structured. The students have to just sit down and be quiet.

A life science teacher said, "A 25 to 1 student/teacher ratio is what I've always been taught is optimal." Laboratory work should be done in groups of five, because of the availability of materials. With a class size of 35, "one kid answers the question, half the kids don't understand it, and you go on," he said. A small class helps with grading. He said, "If I had small classes I would do more writing. When class size is large, I'm just checking to see if they're working. The class is functioning lower on the taxonomy." He added, "I don't want to do a lot of laboratories because of the large class sizes that I have." In colleges, large lecture classes and small laboratory classes work well.

In summary, the educators who participated in interviews and focus groups felt that small class size, ideally 15 students, but practically 24 students, allows teachers to provide feedback, to check for understanding, and to effectively do hands-on learning. They felt that it allows teachers to better know and understand their students as individuals. Safety is a concern with large science classes.

The experts who participated in interviews and focus groups also shared their views regarding small class size. According to a psychologist, small classes offer more opportunities to experiment. Class size should be 15 to 20 students. She said, "In a small class, students get more opportunities to interact with the teacher. In a large class you have more need to discipline, with a smaller class they have more respect for each other."

"When it comes to class size," stated a physician, "the smaller the better. A great class size would be 10." More interaction with the teacher and each other would occur. In a small class the high achievers can interact with the low achievers. He said, "In a large class, the low achievers would not interact, they would just hang out. You haven't learned until it comes out of your mouth; in a large class you may not be heard from."

A nutritionist said that class size should be 15 to 20 students. A zoologist said that classes should have no more than 23 students. Small class size permits more one-on-one development of the knowledge. A large class usually gets unruly and out of control. A cosmetologist commented that when class size is small there is more student involvement. "With a large class-size, kids get left behind," she said.

In summary, the experts who participated in interviews and focus groups believed that small classes increase teacher-student interaction, and create better discipline. In large classes, low achievers are not heard from and the class moves on without them. Class size of 15 enables teachers to individualize the development of knowledge.

In conclusion, educators believed that large class size creates safety concerns. Educators and experts agreed that small class size allows for more teacher-student interaction and individualized instruction. Experts wanted class size to be 15, while educators felt that advocating less than 24 was not being realistic. Experts felt that in large classes low achievers get left behind.

<u>Security</u>

In addition to small class size, another characteristic of excellent education in general, and outstanding science education in particular is security. The educators who participated in focus groups and interviews shared their views on this topic. A principal said, "All of the buildings at our school are alarmed at night, so they're secure at night as far as break-ins, theft, or vandalism."

> The whole area is fenced to keep the children in and unwanted visitors out. Everyone goes through the office. Children are trained to let an adult know when a stranger is here. We practice emergency procedures, and provide staff training. There is an annual operational review. Equipment is checked on a scheduled basis.

The principal said, "A behavior plan and the guidance committee address disruptive behavior."

> For children who are prone to violence, we want to know the history, what sets them off, what medication they are on, and for them we use a behavior contract. The most important factor for dealing with disruption and violence would be to

work with the parents. Students who put others clearly at danger would be removed.

"To achieve security," posited a teacher's aide, "don't have a campus with hiding holes; have a functional design." Adjust the security night-lights to the time change. Students can swipe ID cards into a computer for taking attendance. A special education teacher commented that ramps should be caged up waist-high so students cannot throw things or go over. Some students need keys to elevators. A school should have some lights on at night. She said, "You could use ticket books, so that you wouldn't take students to the office for dress code violations or tardies, instead you would let them go to court." She added, "There needs to be zero tolerance for violence; when students are violent, you need to get law enforcement involved."

An anatomy and physiology teacher stated that schools need more security personnel, and better deployment of the ones they have. Schools should use high-resolution security cameras, and require ID badges on kids. A biology teacher commented that a school should separate disruptive or violent students from the rest of the student population. Violent students should have mandatory counseling.

According to a school board member, security is within the individual. "You have to have the courage to stand up. Our students need to know that the report taker will follow up," he said. Teachers shouldn't demean any student; they should let that student leave with dignity. "You need to get the ego out of it," he said.

A mentor teacher noted that a good staff and people with their eyes open provide security. "I hate to see a perimeter fence; it's scary," he said.

> You need security staff, radios; someone needs to be looking in all directions at all times. Teachers should step outside their classes. The principal, assistant, and deans should walk outside their offices. The more people that are visible, the less chance there is for problems.

The mentor teacher said that at nighttime, with security lights and cameras, students know they can be caught. He said, "Disruptive and violent students should be out of there. They are preventing the good kids from learning. I don't think they should get more than three or four chances."

A life science teacher noted that a school could have a guard at the gate. He said, "I think there should be zero tolerance for violence." A physical science teacher stated that there should be more security officers. They could be walking around the school, like the cop on the block, so that they could be dispatched quickly. When a student is sent to the dean, there needs to be consistency. They should not get a warning.

In summary, the educators who participated in interviews and focus groups felt that to achieve security, effective emergency procedures need to be practiced. They felt that students should swipe an identification card into a computer. The participants believed treating all students with dignity attains security.

The experts who participated in interviews and focus groups also shared their views regarding security. A psychologist commented that it is good to have a closed campus. There should be a guard at the entrance, to limit who is on campus. Schools should use metal detectors. To limit disruption, the teachers have a responsibility to provide structure in their room.

A physician commented that faculty should talk to the kids, so that everybody interrelates. A school should get the parents involved on a daily basis. He said, “We’re all afraid to relate to students, because of possible litigation.” When students are disruptive, talk to them away from the other students, and then ask to help them with their problem. Limit disruption by making each student an integral part of the class. “Get violent students out of there,” he added.

A nutritionist posited that a school would improve security by having one or two extra teachers. “When students are violent, bring a cop in and scare them,” she said. A cosmetologist said that schools should use metal detectors. Violent students should be removed immediately. A zoologist stated that they should use video surveillance.

In summary, the experts who participated in interviews and focus groups felt that campus should be closed to provide security. Violent students need to be removed. Metal detectors should be used.

In conclusion, educators believed that emergency procedures should be practiced. To provide security they felt that ID cards should be swiped as students enter classrooms. Students should be treated with dignity. Experts felt that campus should be closed. They believed that violent students should be removed to attain security. Everyone entering campus should have to pass through a metal detector.

Social Activities

In addition to security, another characteristic of excellent education in general, and outstanding science education in particular is social activities. The educators who participated in focus groups and interviews shared their views on this topic. An anatomy and physiology teacher noted that the dances make the students into more rounded adults, with manners. Teachers model it. A student might be motivated in school because of dances. According to a special education teacher, social activities go on in the classroom, and in the science laboratories.

A school board member posited, "Kids don't pass classes because they don't do the work. Social activities can teach them study skills." Scouting and the Peace Builder program teach good manners and courtesy. Social activities should be positive and comfortable. These activities should be bi-lingual for more families to participate.

According to a mentor teacher, the morale of the kids is very important.

> Dances and games should be well chaperoned. Band, auto shop computers, sports, dances, drill team, cheerleading, Spanish club, Christian club, fencing club, and chemistry club are the reasons some kids stay in school. It's a diversion to give the students something to look forward to rather than just learn, learn, learn. There should be a late bus to take the kids home.

In summary, the educators who participated in interviews and focus groups felt that students develop manners, study skills, and leadership by their participation. The participants believed that activities such as band, auto shop, cheerleading, dances, drama, and debate are desirable. Families should be encouraged to participate in social activities at school.

The experts who participated in interviews and focus groups also shared their views regarding social activities. A psychologist noted that students need a healthy atmosphere to learn in. Social activities help them to feel they belong. They identify with the school, and see what other students are doing. "Students like to socialize. They should have clubs for academic interests, fun, and community service. Pep rallies are good for students," she said.

A physician noted that social activities are vital. Dances can be where students learn how to interact. Clubs allow a student to demonstrate organizational leadership. Drama and debate are important social activities.

A cosmetologist said that social activities help to keep the students' morale up. Science Club would be a great activity. Math Team would be good. A nutritionist commented, "You can't just learn, learn, and learn, you have to have fun. The activities are good; the students interact."

In summary, the experts who participated in interviews and focus groups felt social activities are important so that students can pursue academic interests, have fun, and perform community service. Dance, drama, and debate are important social activities. Social activities develop students' abilities to successfully interact and to lead.

In conclusion, educators felt that families should be encouraged to become involved in school social activities. Educators and experts agreed that social activities develop cooperation and leadership skills. They agreed that drama, dance, and debate are some of the activities that should occur. Experts believed that social activities provide fun and community service.

Sports

In addition to social activities, another characteristic of excellent education in general, and outstanding science education in particular is sports. The educators who participated in focus groups and interviews shared their views on this topic. According to an anatomy and physiology teacher, "Sometimes playing sports is the only thing that will motivate a kid." A realistic GPA for participation in sports would be 2.5; it would give kids the opportunity to take more challenging courses with less concern that doing so would lower their GPA to the point where they would be ineligible. The requirement for participation could be not below a B in core curriculum, like it is in college with majors. If an AP biology laboratory can be conducted an hour before school, then sports can be conducted during the hours after school. According to a special education teacher, "Sports only benefit a certain number of kids." Participants need to have a B average and above. "As much school as athletes miss, sports are unfair to the other students. They could go to a zero period, so sports would not affect their education," she added.

A school board member commented that sports develop camaraderie. "I like the individual sports, tennis, track, cross-country because everybody plays. With a team sport, all should play. Contact sports are too rough," he added. Attending sports develops social skills. There should be no minimum requirements to participate.

Sports, said a mentor teacher, encourage students to learn because they need to keep a grade point average. It teaches the children responsibility. Eligibility should not be any lower than a 2.0. He said, "If I had my way it would be a 'C' plus or a 'B' minus."

In summary, the educators who participated in interviews and focus groups felt that sports provide motivation and interest in school for some students. Some felt that students should have a 2.5 or higher academic GPA to participate. In team sports, all of the players should play.

The experts who participated in interviews and focus groups also shared their views regarding sports. A psychologist said that students should have opportunities to participate in sports if they do not have athletic prowess. They should have a "C" or above to participate.

According to a physician, "Sports are vital. You have to have a kinetic sense about yourself. In sports, you create strategies, and you relate to others because you can't really do it by yourself. There should be a sport required for each student." Tennis and golf could be offered, but not so much the physically violent sports. Schools should bring the sport to the students. Water polo and swimming are great sports. He said, "Excelling in a sport made my son a better student and a better person. However, we need to make education the number one priority or we'll lose the kids."

"Sports are good," commented a cosmetologist, "because they keep kids interested in school." The minimum GPA needs to be at least 3.0. According to a nutritionist, sports build morale for the students, and they develop teamwork. Students participating in sports should maintain a 3.0 GPA. A zoologist commented that the minimum GPA for sports should be 3.2. A life science teacher stated, "Sports programs encroach on the academic programs."

In summary, the experts who participated in interviews and focus groups believed that all students should have the opportunity to participate in sports. Sports create an interest in school for some students. Some experts believed that participants should be required to maintain a 3.0 GPA or higher.

In conclusion, the educators and experts agreed that sports create motivation and interest in school. They agreed that all students should be able to participate in sports. Some educators believed that students should have to maintain a 2.5 GPA or higher to participate in sports, while some experts felt that their GPA should be 3.0 or higher.

<u>Industry Support</u>

In addition to sports, another characteristic of excellent education in general, and outstanding science education in particular is industry support. The educators who participated in focus groups and interviews shared their views on this topic. A principal commented that industries could provide opportunities for children to visit. "In science there are researcher, college professor, there are so many career opportunities. Schools should not just ask for money. For some children it could be their ticket to going on to further education because of a field trip," she said. Industry can provide speakers at career days. There is not an industry where science is not involved.

> The partnership needs to be 50-50; a school needs to identify how they can help the business. We've worked with the hospital, by providing home study in the pediatric ward, and working with child cancer patients. This requires a monitor in the classroom, and access to a library for the children, staff, and parents.

A biology teacher stated that industry could provide funding. Have them donate a bus to take students to where they work. Medical centers, companies that do gene research, and the electrical and solar industries could contribute to schools. According to a special education teacher, businesses should send volunteer scientists to come talk to students. Students should visit the game and fish department and the San Andreas Fault. A teacher's aide noted that the cement plant is open to tours, but it is the bussing and the substitute that prevents students from going. "All of the business people should contribute, like mechanics at a garage, cooks at a bakery, and others," she said. According to an anatomy and physiology teacher, "UCLA, Loma Linda University, the Dryden Space Center, the United States Geological Survey, and the Jet Propulsion Laboratory all should have somebody constantly bothering us instead of us stumbling upon them."

A school board member stated that industry does support education. Businesses donate machines. They need to tell young people to get more education, and to teach. Industry can help the colleges develop teachers. The Jet Propulsion Laboratory could let students use their telescopes. Cement companies could support education.

A mentor teacher stated that, "I like to see businesses taking students out and training them for jobs. The teacher needs to go out and find out who's willing to help out."

> Pfizer used to give minerals to the schools. They upgrade stuff every year, and they have old stuff that can be used with the kids. Other businesses that could support schools include pharmaceuticals, aeronautics, engineering, and computer technology. Best Buy and Circuit City could help with old software that they take in trade. Target has adopted a school. K-Mart gives backpacks. Go out and beat the bushes and you'll find a lot of places that will donate.

A physics teacher commented that businesses are locally oriented. Business speakers should come to talk to the students. They could help the kids to realize that they do not have the needed qualifications. Lockheed could provide support. A physical science teacher noted, "The administration won't get substitutes to let teachers go to industry. Teachers should be job shadowing. Students should be taking field trips to businesses." A life science teacher said, "I would like businesses to offer, instead of us seeking them out."

> The companies could tell us how they plan, and what information they use. Students could perform problem solving with them. Industries should have an educational specialist or division.

In summary, the educators who participated in interviews and focus groups believed that students should have opportunities to go on field trips to local industries. Visitors from industry should come to schools to talk to students about their work. Industry should donate money, supplies, and materials to schools.

The experts who participated in interviews and focus groups also shared their views regarding industry support. An astronomer noted, "Scientists need to be able to create new ideas. The more that they know, the more they can come up with. What is most important to science education is knowledge of space." He said NASA should make more visits to schools to let students know what they are doing, like the work they are doing with the international space station and the rovers. They could share what they do and know, and let students know how they can do what scientists do.

According to a biologist, there is a role for industry in science education. Students should be performing inquiries into applied subjects. Industry can provide lessons that go into real-world science problems that students could work with. Industry can supply equipment or money without strings attached.

Internship programs, noted a physicist, develop student interest in science.

> An internship program gets students involved in practicing science. What attracts students to science is difficult to convey in the classroom setting. When students participate in internships, people rely on them. It increases

their self-worth, they feel respected and needed, and that creates motivation.

A psychologist said that corporations need the schools to graduate good science students. They should provide grants and recognition. The computer industry, manufacturing, and technical businesses should support science.

According to a physician, industry should put their money into the classroom. The teachers should contact the industries. Teachers could bring the executives into the classrooms, have them interrelating with the kids, and then they could show them what is needed. "I bought owl pellets for the school with one stipulation, that I got to come help take them apart," he said. Industry can supply owl pellets, sheep eyes, and fish.

A cosmetologist commented that businesses should make donations of their products and their time. Schools should not limit the buses so that students can visit companies. Students could visit hospitals. A nutritionist said that the military should supply things; they could share their equipment, like their telescopes. Students should go to businesses. According to a zoologist, companies in agriculture could supply worms for dissections and slides of bacteria for examinations. Students could visit aerospace manufacturers.

In summary, the experts who participated in interviews and focus groups felt that industries should provide support by visiting schools and letting students know what scientists are doing in the real world. They felt that industries could provide information to allow students to make inquiries into applied subjects. The participants believed that internships develop student interest, self-worth, and motivation.

In conclusion, educators believed that industry should support education by providing opportunities for field trips to businesses. They felt that industry should provide supplies and funding for education. Educators and experts agreed that visitors from industry should come to schools to let students know about the real world. They agreed that industry should supply information for student research. Experts felt that students should participate in internships in industry.

Cafeteria

In addition to industry support, another characteristic of excellent education in general, and outstanding science education in particular is the cafeteria. The educators who participated in focus groups and interviews shared their views on this topic. A special education teacher commented, "A hungry kid is thinking about other things." Good nutrition is important for brain development. Students need a place where they can sit down to eat. "Some kids won't eat because they won't stand in line for a long time," she added. An anatomy and physiology teacher said, "The cafeteria takes their minds off food so they can focus on education." A school should have a licensed dietician. Students are eating fats, sugars, and salts, which make them more sluggish or hyper. Schools should go to non-caffeine soda machines.

A school board member said, "We need to have control of our diet, with not much candy or pop." He asked, "How many times do you have a pretty good discussion over a meal? At a cafeteria you should learn social skills." Nutritionists should be in charge of the menu. There should be a pleasant environment. He added, "You can't think without a full stomach."

A mentor teacher said that a good cafeteria keeps students healthy. Everyone needs a break. "I'm not in favor of the moneymaking stuff like potato chips, candy, and soda pop.

I'd like to go to a full-course meal or a buffet line," he said. "I think that the state should keep the fat and calorie content down. It's not good for the kids to get hyped-up on sugar," he added.

A physical science teacher commented that for some kids, "The cafeteria is what gets them to school. Students need breakfast and lunch."

In summary, the educators who participated in interviews and focus groups felt that the cafeteria is important to provide nutrition and brain development. They felt that students do not concentrate on academics when they are hungry. Some students come to school for breakfast and lunch.

The experts who participated in interviews and focus groups also shared their views regarding the cafeteria. The menu, according to a psychologist, should be healthy food, and there should be a selection. The food should appeal to the students, but it should not be junk food.

A physician commented that students have to eat well. The cafeteria addresses their emotional needs too. He said, "If you are hungry you can't think." Cafeterias are too regimented; students should be able to eat whenever they want to eat. In addition to meals, there should be a nutrition break. Pizza is a good food.

According to a cosmetologist, food nourishes students' bodies so that their minds work. The meat should have no more than 2% fat. The cafeteria should be clean. A nutritionist noted, "People have to eat. The food should be nutritious." A zoologist said that the cafeteria should serve Grade "A" meat.

In summary, the experts who participated in interviews and focus groups believed that the food should be appealing, but that schools should not provide junk food. Students should be able to eat when they are hungry regardless of schedules. The cafeteria should provide a pleasant, clean environment.

In conclusion, educators believed that the cafeteria should provide nutritious foods that are important to development. They felt that breakfast and lunch are what motivate some students. Educators and experts agreed that students should eat when they need to so that they can concentrate on their studies. They agreed that the cafeteria should provide a pleasant environment. Experts felt that schools should not provide junk food.

This chapter has reviewed the results of the survey, focus groups, and interviews. The next chapter will present the implications of the study and suggestions for future study.

CHAPTER FIVE: Implications of the Study and Suggestions for Future Study

This fifth chapter will present and discuss the implications of the study. It will provide suggestions for future study. It will present the proposed plan for a science-centered magnet school.

Implications of the Study

The most important suggestion from this data is that qualified instructors and hands-on experiments should be strongly emphasized in the design of a school that provides excellent science instruction. Computers should also receive a strong emphasis. These features are likely to receive the enthusiastic support of both parents and students.

Parent support is conventionally sought for the design of a school. The data indicate that parental support for a school would require the significant inclusion of reading and writing and classroom facilities in the design.

Student support may make the difference for a school to be effective. The data indicate that student support for the design of a school requires that social activities and laboratory equipment would be important features.

The desires of smaller groups with specialized characteristics may become important factors for the success of a school. The data indicate that many students and parents feel that qualified instructors and security are the most important features for the design of a school. Many students feel that sports is the most important feature, and many parents feel that reading and writing is the important feature of an effective school.

I am most surprised to find quality instructors ranked overwhelmingly as what students and parents feel is most important. Schools commonly talk to parents about test scores or their facilities, while this result indicates that they should be investing their resources into and telling the parents about the qualifications and training of their instructors.

I think that it is interesting that parents do not believe that computers are as important as students do. I think that this indicates that students have a more current view of the world that they will be entering, and that their parents will need to be educated about this situation to enlist their support to acquire technology.

I feel that the large differences in rankings for social activities and sports, which students value much more than parents, are cause for concern. This needs to be addressed so that parents will support these factors that may be essential to student motivation and involvement.

Suggestions for Future Study

As a suggestion for future study, I would like someone to set up a dozen schools as test groups. At each of the schools, one of the 12 factors discussed in this study would be improved. These would be matched against otherwise similar schools utilized as a control group in which no change is made. Each of these schools would be measured to determine the effect of these improvements in terms of academic achievement by students.

As an alternative suggestion for future study, I would like someone to conduct a survey of graduate science students. This would be useful in addition to the current study, for as students progress through colleges they gain understanding about how their academic coursework is preparing them for their future careers.

The Wilkins Institute for Science Education

The factors identified in this study cannot be adequately implemented in a regular school setting. It is clear that a specialized setting that logistically and philosophically concentrates these factors is necessary. I believe that a science-centered magnet school could be designed to provide quality science instruction by emphasizing the items parents and students have indicated that they value most. For this reason, I will now present my proposed plan for a science-centered magnet school, the Wilkins Institute for Science Education.

The Wilkins Institute for Science Education (WISE) will not be a traditional school. The WISE will blend multiple strategies to deliver excellent science education. It will offer science courses to students while they are concurrently attending existing elementary and high schools. It will also provide science-centered education in all subjects to students who attend the WISE full-time. It will bring science lessons to students at their school locations. It will also provide science lessons to students who visit the WISE campus. The blend of these delivery methods will change over time to achieve compliance with the needs of students. A monorail, the Internet, teleconferencing, and other methods will be used to deliver instruction. The WISE will utilize future technologies as they become available to optimize the delivery of excellent science education.

The WISE will change the world. This plan provides the mission for the WISE. The district office, in establishing the WISE, will agree to this mission. Teachers, as they join the school, will agree to this mission. Parents and students, as they enroll in this school, will agree to the mission. Teachers will determine how this mission will be accomplished in the operation of the WISE. Parents, students, and business partners will participate in meetings with teachers in which they will be asked to share their values and to contribute their guidance. Others who will be asked to help to provide direction will include members of the community, extended family members, and government officials.

WISE Schedule

The WISE will follow a 9-5 daily schedule. Schedules for students will be highly variable. Schedules for courses will be very flexible. There will be no bells or buzzers. Teachers will peacefully guide younger students. Older students are assumed to be mature, so they will be given the responsibility to comply with schedule requirements. At least 2 hours of each day will be dedicated to social activities, some science based, others purely motivational and fun. Teachers will be equally involved in the planning and administration of academic and social activities.

Students will not need to take any single course from start to completion. They can attend only the labs and lectures that they wish to. They can attend any class on any day. If space is not available, priority will be given to students who have attended prior sessions of the course. They will receive credit for completing a course when they have passed all of the tests, lab exams, interviews, and exhibitions for that course. This will allow students to custom blend their education to their own needs and interests.

WISE students will make progress scholastically at their own pace. They will move from grade to grade at any time that they have passed the tests for the courses associated with that grade. The time spans for the completion of courses will meet individual requirements. Students may attend lessons and take tests for a course over a period of several years, or they can complete the course in a few months according to their individual abilities. Students can complete the requirements for high school science in 3 years or fewer, or in 5 years or more, according to their ability to do so. The designation of grade will only be used as an indicator of progress, and will not be used to establish arbitrary expectations, or to limit an individual's potential for learning.

WISE students in grades 11 and 12 will receive 12 hours of science instruction each week, provided in eight lessons of one hour each, and two laboratory sessions of 2 hours each. Students in grades 9 and 10 will receive 8 hours of science instruction each week. Students in grades 7 and 8 will receive 6 hours of science instruction each week. Students in grades 4 through 6 will receive 3 hours of science instruction each week. Students in grades kindergarten through 3 will receive one hour of science instruction each week.

"Primavera" or an equivalent software program will be used by the WISE to perform scheduling. The software will allocate limited resources, respond rapidly to revisions, and will optimize the schedules according to predetermined priorities. All students will have all of the classes that they will attend, freshman through senior year, scheduled from the day that they enroll. Students will identify possible academic and career goals, and then the computer will monitor the compliance between the courses they take and the prerequisites, activities, and other requirements they need.

Table 8

WISE Weekly Schedule

Grades	Lessons Quantity	Lessons Minutes	Laboratory Quantity	Laboratory Minutes	Total hours
11 – 12	8	60	2	120	12
9 – 10	6	60	1	120	8
7 – 8	4	60	1	120	6
4 – 6	4	30	1	60	3
K – 3	3	20	---	---	1

Instruction will evolve from WISE instructors traveling to the elementary schools to deliver lessons to students in the primary grades, to secondary grade students traveling to the WISE facility for laboratories while other lessons are delivered at their schools, to middle school students being transported to the WISE for many of their lessons, and to high school students being transported to the WISE for all of their lessons. Lessons at the WISE facility will utilize equipment that is not easily transported, such as a telescope, a class set of microscopes, a chemistry experiment, a dissection, or a computer lab.

WISE Curriculum

Schools should coordinate science instruction from grades K to 12. It should be managed collectively by all of the schools' teachers. Science instruction should be provided at magnet schools to students at existing elementary and high schools. The participation of parents will be critical to the success of these schools.

All laboratory lessons at the WISE will be hands-on. All students will engage in action research. They will perform all experiments, using materials and equipment suitable to the tasks. Students will not merely observe demonstrations, in place of doing science themselves. They will design experiments, make observations, and reach their own conclusions.

Kits will be created at the WISE for each hands-on laboratory lesson. The kits will provide the materials in the quantities needed for the lessons, and will identify the location of large or expensive equipment that will be used. The kits will contain instructions for the teacher and videos of the lessons being performed so that teachers can be well prepared to present all of the laboratory lessons to students. The instructors will be responsible for replenishing the consumable materials, reordering materials if needed, and replacing the equipment immediately after performing the lesson.

Instruction will be delivered to WISE students by the most efficient method possible according to the requirements of the lesson being taught. Lessons will be brought to classrooms and multi-purpose rooms at area schools, to distant classrooms via the Internet with telephone communication capability, and students will wear seatbelts while traveling by monorail to the WISE facility.

Teachers will work collaboratively to create all lessons used at the WISE. Each year it is expected that all teachers will replace the most ineffective or out-of-date 20% of their lessons with current, better lessons. Teachers will be encouraged to try new methods, to take risks, and to learn from failures. To develop curriculum they will have access to resources such as literature, current journals, Internet reports, information provided by business partners, and other sources. Textbooks may be used by teachers as resources to develop lessons, but they will not be used in the classroom.

WISE students will attend 2,600 hours of science instruction during grades kindergarten through 12. Subjects will include Astronomy, Meteorology, Oceanography, Geology, Environment, Physics, Chemistry, Microbiology, Zoology, Marine Biology, and Anatomy and Physiology (see Table 9).

Table 9

WISE Yearly Curriculum

Grades: K – 12	Total science hours (520 weeks): 2,600
Grades: 11 – 12	Science hours per year (40 weeks): 480
Grades: 9 – 10	Science hours per year (40 weeks): 360
Grades: 7 – 8	Science hours per year (40 weeks): 240
Grades: 4 – 6	Science hours per year (40 weeks): 120
Grades: K – 3	Science hours per year (40 weeks): 40

Grades	11 – 12	9 – 10	7 – 8	4 – 6	K – 3
Subject	Hours per year				
Astronomy	40	30	20	10	3
Meteorology	30	20	15	10	3
Oceanography	30	20	10	5	3
Geology	50	40	30	15	5
Environment	40	30	20	20	10
Physics	50	30	20	5	---
Chemistry	50	40	30	5	---
Microbiology	50	30	20	5	---
Zoology	40	30	20	20	10
Marine Biology	40	30	20	10	5
Anatomy	30	30	20	10	3
Physiology	30	30	15	5	---

Assessment at the WISE

WISE students will take all tests using computers at the testing center. The programming will select a sampling of questions from a large database, so that each student who takes the test will receive different questions. Students will be isolated and filmed while they are taking tests. These steps will ensure that cheating will be minimized. Instructors for each subject area need to create the database of questions. Representative parents and students need to be able to review the questions to assure that the standards that they have identified are being evaluated. Programming should score the tests and provide results to the teachers. The testing center is also where standardized tests will be administered. Having had experience with the environment and the format will enable students to excel on standardized tests that are required by the state. This will also eliminate the need to take instruction time away from the instructors.

Industry has identified the inability to work with others as the most common reason for termination of employment. To address this need, not only will WISE students learn interpersonal skills and participate extensively in group assignments, but they will also be assessed collaboratively when appropriate.

All WISE students will do science. The WISE will teach science to students at the elementary, middle, and high schools. This will create cooperation between the elementary and the high school districts. The elementary district would have more incentive to cooperate if state standardized testing measured science during the elementary years (in California, it does not). In lieu of this, the WISE will have to demonstrate how science instruction improves achievement in math, reading, and writing.

Grades at the WISE will also be based upon interviews. Interviews will be used because they are the primary evaluation mode used by industry. Instructors will conduct one-on-one interviews with students on a regular basis. The questions used in these interviews will be oriented toward determining if the student understands the academic content of the courses.

Teachers at the WISE will meet on a regular basis with small groups of students. During these meetings, course content will be discussed, and relevant controversies and ethical issues will be considered. It is the intent of these meetings to explore course content in-depth, and for students to develop deep understanding.

Since parents and corporate sponsors will be providing significant funding for the WISE, evidence will need to be provided to them that the school is delivering excellent education as promised. A standardized test to serve this need for accountability will be developed by the WISE. Parents, students, and business partners will be asked to contribute to the development of the WISE's standardized test. The WISE standardized test will not be restricted to paper and pencil, nor will it merely evaluate an accumulation of facts.

Students will also need to take the standardized tests required by the government of the state. Any assessment of students whose primary aim is to measure the effectiveness of the school or the teacher will be conducted by sampling all of the students, rather than having each student provide comprehensive assessment, thus limiting the amount of time that each student is removed from instruction. In the case of standardized assessment required by the state, this may require the revision of laws or policies.

Industry Participation at the WISE

Industry has lamented that schools are not teaching the skills they need. Schools need to give industry the opportunity to identify and include the skills required in the curriculum, and to provide the resources to enable the skills to be developed. The community has complained that American education is in decline. Schools should provide their chance to actively work toward solving the crisis.

Every student at the WISE will perform apprenticeships. These will occur in the last years prior to high school graduation. The school will coordinate the placement of each student into a position that is of interest to him or her. Students will prepare for their apprenticeships by utilizing modeling simulation software to role-play as scientists. Apprenticeships will give students the opportunity to implement the skills they have learned at the WISE by working with real problems in real settings in the field of science. Apprenticeships will help WISE students to not only know a lot about their subjects, but to do something useful with their knowledge, to be able to create meaningful change.

WISE students will join with mentors, scientists who are currently employed at NASA, Boeing Aerospace, Hewlett-Packard, hospitals, colleges, agriculture, and other science-based industries. Mentors will communicate with students by e-mail, they will host field trips when the students will visit them at their worksite and will participate in some of their duties, and mentors will help to facilitate opportunities for students moving into college and the workforce.

From the time of enrollment, all WISE students will have mentors. Mentors will be scientists who are currently active in the fields of science that are of most interest to each student. Mentors will maintain regular supervised contact with the students. Mentors will be positive professional role models. WISE mentors will provide training, coaching, access to information, and may eventually be able to help with career placement.

Corporations in the field of science will be asked to contribute financially to the WISE. This will allow for the acquisition of state-of-the-art laboratory equipment. It will enable the creation of a WISE facility that will be innovative and inspiring.

The partners of the WISE will be participants from businesses in the field of science. The teachers and parents will seek these partners. Partners will be asked to provide funding, allow students to perform apprenticeships, send mentors to provide instruction, and to make resources available to teachers. In return, the WISE will provide students who will, upon graduation, be employable as effective scientists.

Student Involvement at the WISE

Social interactions among students often motivate educational success. Interrelationships between teachers and students include roles as liaison to the environment-participant, producer-actor, and facilitator-creator of an individualized product. The education system needs to be integrated between the classroom and the environment. Students should be outside of the classroom, traveling in a small plane and a boat; seated at the Jet Propulsion Laboratory and the Schubert Theater; touring the General Motors assembly line and Independence Hall; and viewing glaciers in Alaska and geysers at Yellowstone.

Motivation will be a primary emphasis of the WISE. Music, sports, and the arts will utilize state-of-the-art facilities and materials to lead motivational programs for the student body. Participation in athletics, speech and debate, drama, cheerleading, music, student government, and art will be utilized to develop motivation. Activities will include dances, lectures, concerts, theater, individual and team sports, special interest clubs, ice cream and soda shops, and others. All WISE students will fully participate in as many of these activities as they would like to. Participation in activities will not be limited to a privileged few.

The resources available to all students will be equal. The WISE will have intramural activities, such as athletic teams, the same as traditional schools. In addition, equivalent activities will be available to all other students. In these alternative activities, students will wear uniforms, play in a stadium, compete against other teams from their school, and overall will have an equivalent experience.

The emphasis of athletics and activities will be to develop lessons of fair play, of working for what you get, to develop an appreciation of esthetics, and to build creativity that will reach into the academic disciplines.

WISE students who participate in intramural activities, part-time work, or other extra-curricular activities that are supported by the school will be required to have a cumulative minimum 3.0 grade-point average to begin, and will need to maintain a minimum 2.5 grade-point average in each current grading period to continue to participate. They must also have acceptable attendance, and they must have no significant disciplinary infractions.

Students can work for an hour before and after school, cleaning the WISE facilities. Students will be paid $10 per hour, which is expected to be an attractive wage. It is anticipated that having the students perform the maintenance will develop a respect for the proper care of the WISE facilities.

WISE Teachers

Full-time WISE teachers will be chosen from among the best science teachers currently at the middle and high schools. Some excellent science teachers who wish to maintain their commitment to their school will be chosen as part-time teachers. Part-time and full-time WISE teachers will also be recruited from among scientists who will be concurrently active in science-based industries. Teacher compensation will be determined by three factors of equal weight: the current market value for teachers employed by traditional schools, the achievement of the students as determined by standardized tests, and the financial viability of the school.

Quality education can best be achieved when teachers lead the school. Having teachers as the leaders will place the emphasis upon curriculum and instruction. At the WISE, all administrative duties usually performed by principals, counselors, and secretaries, will be performed by teachers. There will be no full-time administrators; all staff members will primarily be teachers. A vision statement will be created and revised through the participation of teachers, parents, students, and participants from community and industry. Teachers will meet daily and work together to implement the vision.

Training for teachers should be meaningful and abundant. The development of quality instructors is the most important investment that a school can make. Instructional time will be flexible so that training will not reduce the amount of instruction. Teachers at the

WISE will receive training regarding science, instruction, school administration, psychology, and other subjects.

WISE teachers will work together. Teachers can teach individually or together to optimize the instruction of each lesson. Veterans and newer teachers will be able to share their knowledge of science and their skills as instructors, to enhance the abilities of all teachers to best serve the needs of the students.

Teachers, in addition to their duties teaching at the WISE, will actively participate in the field of science. Active scientists as well as professional teachers will be sought to serve as instructors at the WISE. This may require some accommodations for the laws of the state regarding the credentialing of teachers at public schools.

WISE Students

All WISE students and staff will be subject to frequent drug tests, administered at random times. Searches for weapons and for controlled substances will be conducted on a regular basis. At the WISE facility, all teachers will provide supervision during times when students are out of the classrooms. A roving teacher will provide breaks for teachers during classes. Discipline will be separated from instruction. Students whose behavior is disruptive will be asked to leave the classroom, and their conduct will be considered at a later time.

Attendance at the WISE facility will be automated. Teachers will not participate in taking attendance, which will allow them to spend all of their class time providing instruction. Teachers will call absent students to coordinate remedial lessons, and to reinforce the commitment to learning. Students will carry identification cards. Scanners in each classroom and break area will monitor the movement of all students at all times. If a student is not present at the WISE facility and parents have not cleared the absence, the computer will notify security and the parents immediately. Security will periodically verify that students are carrying the proper identification. Teachers and parents will be able to receive a summary report of a student's attendance.

Students will take turns participating in meetings in which they will consider actual instances of misconduct by students, and will determine the disciplinary consequences. This will require the prior agreement by all students to limitations in confidentiality. Student participation in discipline will not be appropriate for sensitive or severe instances of misconduct.

Each student at the WISE will have his or her own computer station. Technology for the WISE will feature a software system that is used by the students in place of textbooks, paper, and pencil.

Effective patterns of study need to be taught to all students. The WISE will challenge the structures in school systems that are based upon the factory model. It will reshape boundaries between administrators, instructors, parents, and students. Curriculum needs to reach across hierarchies that divide knowledge by academic subject to produce new learning, in the manner used by Albert Einstein, Henry Ford, and B.F. Skinner.

The beliefs and value systems of students determines the accommodations to the school content and structure needed to provide an excellent education. The connections and relationships to a school system that are valued by parents need to be considered.

Students at the WISE will utilize accelerated learning methods such as MASTER, the VAK Attack, and accelerated memory methods. WISE students will develop their emotional intelligence. They will reflect critically, and they will utilize a resourceful state. Instruction at the WISE will address the multiple intelligences of students. The genius of each student will be developed.

All teachers at the WISE will meet with all students and with all parents on a regular scheduled basis. All teachers will recognize and know all students by name. Booklets with pictures and names will be provided to teachers. Information about all students will be provided to all teachers so that they might know the interests, needs, and other relevant background of the students. Time will be allocated for teachers to study this information, and to collaborate with other teachers so that they can develop strategies to use this knowledge to benefit the students.

Student diversity will be sought at the WISE. It is important that all students, regardless of age, gender, ethnicity, or other category of diversity, should know that they can do science. When they are the best qualified, the WISE will utilize teachers of diverse ethnicity and gender. Students will benefit from seeing teachers, who are similar to themselves, performing science.

The WISE will not use students as teachers' aides, offices aides, or similar non-academic functions. Not only is this a misuse of a significant portion of a student's time, but it also opens up the school to liability for the times that a student is alone with the teacher, as well as creating the potential opportunity for harm such as sexual or physical abuse to be inflicted upon an isolated student.

WISE Facilities

The WISE facilities should be created by the best method available to provide an excellent educational environment. The facilities can be created by new construction, or by upgrading an existing school facility. A portion of an existing large school facility can be used to create the WISE facilities. A commercial facility, such as a warehouse, can be adapted to provide facilities. The facilities of the WISE will utilize solar panels, windmills, and wells. Grey water will be used where applicable. The WISE facility will provide to students a model of responsibility to their environment.

It is very important that the WISE facilities will be comfortable, modern, and very well maintained, so that students are motivated to do their best work. If a school campus is covered with trash and graffiti, and the library is stocked with worn texts from the 1960s, why would you expect that students would work to their potential? The WISE facility will have grass areas, trees, and a pond. There will be a multi-purpose room with quality sound and video systems for academic and motivational presentations.

Good tasting, nutritious food will be brought to the WISE students in their classrooms at breakfast, snack, and lunch times. Some menu choices will be provided. The WISE will not have vending machines.

Study rooms at the WISE will be available for students to study, rest, and meet. These areas will have comfortable chairs, tables, headphones for music, modems, meeting rooms, and other useful resources. The library will have a generous supply of relevant books and current journals. Students will search a computerized index, and their selections will be delivered to them.

The WISE classrooms will have warm lights and padded seats. Each student will use a laptop computer provided by the school. This will allow most work to be done with a word-processor; it will allow access to information via the Internet, and it will enable the WISE to create digital portfolios.

The WISE campus must remain small. This will prevent students from being anonymous, and will limit administrative duties to a level that can be handled by the shared efforts of the instructors. If growth exceeds 250 students, the WISE will be split into a second facility.

Students will travel to and from the WISE via an elevated electricity-powered monorail, the Soar. Students will wear seatbelts while they travel safely and securely to and from the WISE. The Soar will have stations at each of the schools in the local area to facilitate transportation of students between these schools and the WISE. The line will run for several hours prior to and after school to facilitate transportation for library use, and for attendance and participation in social, athletic, and other special events. The Soar will be cheaper to operate than buses. Its electric power will not pollute the air. The Soar will not have the safety, security, traffic, manpower, and maintenance problems that buses cause. To provide service to the community, the Soar will have stations at shopping centers, parks, and other high traffic areas, and it will be available for public use during weekends, evenings, and holidays. A key reason that the Soar is included in this plan for the WISE is to move the focus away from what can most easily be done to provide adequate education, toward a focus on what should be done to provide excellent education.

The WISE will be generously equipped with the state-of-the-art equipment needed to perform investigations. Graduates should be expected by future employers to be able to do science. This requires that they have a fully equipped laboratory in which they can perform experiments.

The buildings and landscape of the WISE will be inspiring. The facilities will be clean and well maintained. Students will enjoy learning in this beautiful environment. Students should not be expected to produce excellent results in a school of uncomfortable temporary trailers, sticky classroom floors, and stairwells cluttered with trash.

The WISE will receive one-third of its funding from the state. One-third of the funding will come from the corporate partners. The remaining one-third will come from tuition paid by the attending students. This will be supplemented by grants and donations.

Two-thirds of the students who attend the WISE will pay an hourly rate for tuition. Kindergarten students, who attend fewer hours, will pay a total tuition that is less than high school students, who attend more hours. The total tuition paid by students will be equivalent to one-third of the WISE's net cost for providing instruction. Payment of tuition on the basis of ability will help to create a commitment between the school, the students, and the parents. One-third of the students who attend the WISE will pay a token amount of tuition to establish commitment of the student to the school without causing a financial hardship. These enrollments will be available equally to students with financial hardships or without, based upon their academic qualifications. Making enrollments available at low cost to the students fulfills the WISE's responsibility to the community, and benefits all students by preventing the creation of an elitist environment. Legal obstacles that currently restrict the payment of tuition by students at public schools will need to be considered. These legal restrictions may require that tuition must be in the form of a donation, that the WISE will need to be a private institution, or that the laws will need to be changed.

WISE Subject Areas

Physics: Measurements in experiments, Language of physics, Displacement and velocity, Acceleration, Falling Objects, Vectors, Vector operations, Projectile motion, Relative motion, Changes in motion, Newton's first law, Newton's second and third laws, Everyday forces, Work, Energy, Conservation of energy, Work, energy, and power, Momentum and impulse, Conservation of momentum, Elastic and inelastic collisions, Measuring rotational motion, Tangential and centripetal acceleration, Causes of circular motion, Torque, Rotation and inertia, Rotational dynamics, Simple machines, Fluids and buoyant force, Fluid pressure and temperature, Fluids in motion, Properties of gases, Temperature and thermal equilibrium, Defining heat, Changes in temperature and phase, Controlling heat, Relationships between heat and work, Thermodynamic processes, Efficiency of heat engines, Entropy, Simple harmonic motion, Measuring simple harmonic motion, Properties of waves, Wave interactions, Sound waves, Sound intensity and resonance, Harmonics, Characteristics of light, Flat mirrors, Curved mirrors, Color and polarization, Refraction, Thin lenses, Optical phenomena, Interference, Diffraction, Coherence, Electric charge, Electric force, The electric field, Electrical potential energy, Potential difference, Capacitance, Electric current, Resistance, Electric power, Schematic diagrams and circuits, Resistors in series or in parallel, Complex resistor combinations, Magnets and magnetic fields, Electromagnetism and magnetic domains, Magnetic force, Induced current, Alternating current, generators, and motors, Inductance, Quantization of energy, Models of the atom, Quantum mechanics, Conduction in the solid state, Semiconductor applications, Superconductors, Nucleus, Nuclear decay, Nuclear reactions, Particle physics.

Earth Science: The Earth in space, Models of the Earth, Plate tectonics, Deformation of the crust, Earthquakes, Volcanoes, Earth chemistry, Minerals of the Earth's crust, Rocks, Resources and energy, Weathering and erosion, Water and erosion, Groundwater and erosion, Glaciers and erosion, Erosion by wind and waves, Rock record, View of the Earth's past, History of the continents, Ocean basins, Ocean water, Movements of the ocean, Atmosphere, Water in the atmosphere, Weather, Climate, Stars and galaxies, Sun, Solar system.

Environmental Science: Ecosystems, Interactions of species, Adapting to the environment, Energy flow in ecosystems, Cycling of materials, Changing ecosystems, Forests, Grasslands, chaparral, deserts, and tundra, Freshwater ecosystems, Marine ecosystems, Water resources, Freshwater pollution, Ocean pollution, Air pollution, Acid precipitation, Atmosphere, Climate, Greenhouse Earth, Ozone Shield.

Biology: Biochemistry, Cell function and structure, Homeostasis and transport, Photosynthesis, Cellular respiration, Cell reproduction, Genetics, Nucleic acids and protein synthesis, Gene expression, Inheritance patterns and human genetics, DNA technology, Origin of life, Evolution: Evidence and theory, Evolution of populations and speciation, Human evolution, Classification, Ecology, Populations, Community ecology, Ecosystems and the biosphere, Environmental science, Bacteria, Viruses, Protozoa, Algae and fungus-like protests, Fungi, Plants, Plant evolution and classification, Plant structure and function, Plant reproduction, Plant responses, Animals, Sponges, cnidarians, and ctenophores, Flatworms, roundworms, and rotifers, Mollusks and annelids, Arthropods, Insects, Echinoderms and invertebrate chordates, Fishes, Amphibians, Reptiles, Birds, Mammals, Skeletal, muscular, and integumentary systems, Circulatory and respiratory systems, Infectious diseases and the immune system, Digestive and excretory systems, Nervous system and sense organs, Endocrine system, Reproductive system, Drugs.

Chemistry: Matter and change, Measurements and calculations, Atoms: Building blocks of matter, Arrangement of electrons in atoms, Periodic table, Chemical bonding, Chemical formulas and chemical compounds, Chemical equations and reactions, Stoichiometry, Physical characteristics of gases, Molecular composition of gases, Liquids and solids, Solutions, Ions in aqueous solutions and colligative properties, Acids and bases, Acid-Base titration and pH, Reaction energy and reaction kinetics, Chemical equilibrium, Oxidation reduction reactions, Nuclear chemistry.

9th Grade General Science: Matter, Atoms, Periodic table, Structure of matter, Chemical reactions, Solutions, acids, and bases, Nuclear changes, Motion and forces, Work and energy, Heat and temperature, Waves, Sound and light, Electricity, Magnetism, Communication technology, Universe, Earth, Atmosphere, Natural Resources, Circulation and respiration.

7th and 8th Grades Life Science: Cells: Basic unit of life, Cells in action, Heredity, Genes and gene technology, Evolution of living things, History of life on Earth, Classification, Bacteria and viruses, Protists and fungi, Plants, Plant processes, Animals, Invertebrates, Fishes, amphibians, and reptiles, Birds and mammals, Interactions of living things, Cycles in nature, Earth's ecosystems, Environment, Body organization and structure, Circulation and respiration, Digestive and urinary systems, Communication and control, Reproduction and development.

7th and 8th Grades Earth Science: Maps as models of the Earth, Minerals of the Earth's crust, Rocks and minerals, Energy resources, Rock and fossil record, Plate tectonics, Earthquakes, Volcanoes, Weathering and soil formation, Flow of fresh water, Agents of erosion and deposition, Oceans, Movement of ocean water, Atmosphere, Weather, Climate, Sky observation, Formation of the solar system, Planets, Universe, Space exploration.

7th and 8th Grades Physical Science: Properties of matter, States of matter, Elements, compounds, and mixtures, Matter in motion, Forces in motion, Forces in fluids, Work and machines, Energy and energy resources, Heat and heat technology, Atoms, Periodic table, Chemical bonding, Chemical reactions, Chemical compounds, Atomic energy, Electricity, Electromagnetism, Electronic technology, Energy of waves, Nature of sound, Nature of light.

4th through 6th Grade Physics: Motion in one dimension, Motion in two dimensions, Two-dimensional motion and vectors, Forces and the laws of motion, Work and energy, Momentum and collisions, Rotational motion and the law of gravity, Rotational equilibrium and dynamics, Fluid mechanics, Heat, Thermodynamics, Vibrations and waves, Sound, Light and reflection, Refraction, Interference and Diffraction, Electric forces and fields, Electrical energy and capacitance, Current and resistance, Circuits and circuit elements, Magnetism, Induction and alternating current, Atomic physics, Modern electronics, Subatomic physics.

4th through 6th Grade Earth Science: Dynamic Earth, Composition of the Earth, Reshaping the crust, History of the Earth, Oceans, Atmospheric forces, Space.

4th through 6th Grade Environmental Science: Living things in ecosystems, How ecosystems work, Kinds of ecosystems, Water, Air, Atmosphere and climate.

4th through 6th Grade Biology: Cells, Genetics, Evolution, Ecology, Microorganisms, Plants, Invertebrates, Vertebrates, Humans.

4th through 6xth Grade Chemistry: Organization of matter, Language of chemistry, Phases of matter, Solutions and their behavior, Chemical reactions, Organic and nuclear chemistry.

3rd Grade General Science: Nature of matter, Changes in matter, Motion and energy, Waves and wave properties, Electricity and magnetism, Earth and Space.

Kindergarten through Grade 2 Life Science: Cells, Heredity, evolution, and classification, Simple organisms, fungi, and plants, Animals, Ecology, Human body systems.

Kindergarten through Grade 2 Earth Science: Earth's resources, Restless Earth, Reshaping the Land, Oceanography, Weather and Climate, Astronomy.

Kindergarten through Grade 2 Physical Science: Matter, Motion and focus, Work, machines, and energy, Atoms, Interactions of matter, Electricity, Waves, sound, and light.

A Day at the WISE

The proposed plan for a science-centered magnet school that I have offered can be understood for its more subtle qualities and nuances when expressed as a fictional narrative by an imaginary student. For this reason I now present "A Day at the WISE."

I am a student at the Wilkins Institute for Science Education, commonly known as the WISE. Today I am transported to school in the Soar, a monorail with seat belts and air conditioning. During the ride we listen to classical music. The Soar enters into a campus secured by high fences and guards. I walk from the unloading area past trees, grass, and waterfalls to my first class. The classrooms are new, attractive, and clean. Students sit on comfortable padded chairs, under warm yellow lights. My class sizes are small, about 20 to 25 students. I have easy access in the classrooms to computer word processing, spreadsheet, and presentation programs. I learn from certificated instructors who are trained and experienced.

Classes start and end at the scheduled times; there are no bells and no announcements. At lunchtime I eat quality food that I have ordered. After lunch I have a study hour. Yesterday during a study hour I went into the learning center and sought out research on the Internet. Tomorrow I am going into the testing center and taking a test. Today I have a meeting scheduled with some other students to work on a project in one of the conference rooms. On Monday I met with my counselor during my study hour. On Friday I am going to relax in the park area with some friends.

My attendance is taken by scanners in the classrooms that read my badge as I pass. If I were not in my scheduled class on time, the computerized system would alert security that I was not where I was supposed to be. A summary report of my attendance is supplied to my parents. Today I needed to leave class to go the bathroom. I went to a clean, safe bathroom that could only be used by one person at a time. Students maintain the bathrooms, so we do not vandalize them because we would be the ones cleaning it up.

My grades are based on tests that I take at the testing center. At the testing center, there is no cheating, because you are on the computer by yourself when you take the test. They film you, so if you scored too high they could check to see if you had notes. The questions on the test I take are selected at random from a database, so I would not be able to find out the answers from another student.

This Thursday afternoon I am playing basketball. All of the students play in leagues. We have nice-looking uniforms, and we play at an indoor court on a hardwood floor. A scorekeeper works a scoreboard and buzzers, we have a referee, and some of our friends are in the stands cheering. Last month I was in gymnastics. Next month I am going to do bicycle motorcross.

On Friday I am attending a chemistry presentation. A chemist from a WISE partner company that develops medicines is going to provide demonstrations and answer our questions. As students, we attend presentations in small groups of up to 50. Next week I am going to a NASA presentation on Mars, and a rock concert. Last week I went to a magic show, and a presentation by the zoo about rhinoceros breeding.

Currently I am an intern at a WISE partner aerospace company. A scientist there is my mentor. I attend work with a mentor one day each month. I share in the scientist's duties, and I learn about the industrial environment. I have had previous internships at a company that develops computer software, and at a company that grows trees. I will continue to do internships while I attend college. After I graduate, my mentors can help me begin my professional career.

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APPENDIXES

Appendix A

PARENT SURVEY

Directions:

Please rank the following items 1 through 12:

1 being the most important for quality science education.

12 being the least important for quality science education.

Write the number (1 to 12) on the line next to the item.

(An example of how to fill out this survey is attached).

_____ Campus Security

_____ Social Activities

_____ Sports

_____ Computers

_____ Reading and Writing

_____ Hands-On Experiments

_____ Small Class Size

_____ Qualified Instructors

_____ Classroom Facilities

_____ Laboratory Equipment

_____ Industry Support

_____ Quality Cafeteria Food

STUDENT SURVEY

Directions:

Please rank the following items 1 through 12:

1 being the most important for quality science education.

12 being the least important for quality science education.

Write the number (1 to 12) on the line next to the item.

(An example of how to fill out this survey is attached).

_____ Campus Security

_____ Social Activities

_____ Sports

_____ Computers

_____ Reading and Writing

_____ Hands-On Experiments

_____ Small Class Size

_____ Qualified Instructors

_____ Classroom Facilities

_____ Laboratory Equipment

_____ Industry Support

_____ Quality Cafeteria Food

Appendix B

SURVEY INSTRUCTIONS

This survey is being conducted to determine what is desired for quality science education. The opinions of students and their parents are being sought because of the vital roles in education that you fill, and with respect for your knowledge and the value of your opinions.

Mr. Gary Wilkins, a science teacher at Small City High School, and a student at the Fielding Graduate Institute, is conducting the survey, which will be used in his Doctoral research. Survey results will be provided to participants. Your participation is greatly appreciated.

(Below is an example of how the survey should be completed)

Please rank the following items 1 through 5:

1 being the most enjoyable.

5 being the least enjoyable.

Write the number (1 to 5) on the line next to the item.

__2__ applesauce

__3__ potatoes

__4__ bananas

__1__ grapes

__5__ broccoli

Appendix C: Parent Survey Consent Form

The goal of this survey is to determine what parents and students believe is important to science education. Participants are asked to rank factors that they think are most important. Students and parents are expected to take approximately five minutes to complete the survey.

Participants are students in Mr. Wilkins' science classes and their parents. Participation is voluntary, and the refusal or withdrawal of a participant from the study will not constitute a penalty and their data will be removed and destroyed. To attain confidentiality I will only identify the subjects as parents and as students. I will not disclose the names of the participants. Participants may develop slight anxiety as a result of the insight regarding educational factors that the research should create, if this occurs, students can be referred to school counselors, and parents can be helped to find support. I will discuss with any subject any concerns that they may have. Participants could be benefited by improvements in science education that may occur as a result of this survey.

The survey is conducted as partial fulfillment of requirements for my Educational Doctorate (EdD) at the Fielding Graduate Institute. The data will be used for my dissertation, a knowledge area, and possibly for future books, articles, and academic publications. The Research Ethics Committee of the Fielding Graduate Institute retains access to signed informed consent forms. Please contact me with any questions.

Participants are requested to print and to sign on the lines below:

____

Name of parent or guardian (printed) Date

____

Signature of parent or guardian Date

Thank you for your support,

Gary Wilkins
Teacher, Small City High School
Doctoral Student, Fielding Graduate Institute
13041 Bullet Ave., Victorville, California 92392
(760) 241-5992, debngar@acninc.net

Mark-Scanlon Greene, PhD
Faculty Mentor, Fielding Graduate Institute
922 S. 150th Place, #B201, Burien, Washington 98148
(206) 439-8247, megreene@fielding.edu

Student Survey Assent Form

The goal of this survey is to determine what parents and students believe is important to science education. Participants are asked to rank factors that they think are most important. Students and parents are expected to take approximately five minutes to complete the survey.

Participants are students in Mr. Wilkins' science classes and their parents. Participation is voluntary, and the refusal or withdrawal of a participant from the study will not constitute a penalty and their data will be removed and destroyed. To attain confidentiality I will only identify the subjects as parents and as students. I will not disclose the names of the participants. Participants may develop slight anxiety as a result of the insight regarding educational factors that the research should create, if this occurs, students can be referred to school counselors, and parents can be helped to find support. I will discuss with any subject any concerns that they may have. Participants could be benefited by improvements in science education that may occur as a result of this survey.

The survey is conducted as partial fulfillment of requirements for my Educational Doctorate (EdD) at the Fielding Graduate Institute. The data will be used for my dissertation, a knowledge area, and possibly for future books, articles, and academic publications. The Research Ethics Committee of the Fielding Graduate Institute retains access to signed informed consent forms. Please contact me with any questions.

Participants are requested to print and to sign on the lines below:

____

Name of student (printed) Date

____

Signature of student Date

Parents of participants under age 18 are required to print and to sign on the lines below:

____

Name of parent or guardian (printed) Date

____

Signature of parent or guardian Date

Thank you for your support,

Gary Wilkins
Teacher, Small City High School, and Doctoral Student, Fielding Graduate Institute
13041 Bullet Ave., Victorville, California 92392
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922 S. 150th Place, #B201, Burien, Washington 98148
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Appendix D

PERMISSION TO CONDUCT RESEARCH

(Insert date here)

TO: Principal, Small City High School

FROM: Gary Wilkins, Student, Fielding Institute

SUBJECT: Request for permission to conduct research

COPIES: Mark Scanlon-Greene, PhD, Mentor, Fielding Graduate Institute; file.

Dear Sir,

I am requesting your permission to conduct a survey of the students of my science classes and their parents, to conduct focus group meetings, and to interview parents and community members. The goal is to determine what is important for quality science education. I'll have my students take the surveys at home and take a survey home to their parents. The focus groups will meet at school times adjacent to school hours. Interviews will be arranged at the times and locations that are convenient to the participants. The data will be used for my dissertation and possibly for future academic publications (copies of surveys, and interview and focus group questions attached).

Thank you for your support,

Gary Wilkins, Teacher, Small City High School

I give Gary Wilkins permission to conduct interviews, focus groups, and a survey to determine what the participants think is important for quality science education.

Signature Date

Principal, Small City High School

Appendix E: Focus Groups and Interviews Discussion Questions

The discussion questions that will be used for the focus groups and the interviews follow:

(Introduction): The goal of this discussion is to determine what teachers and experts in the community believe is important to science education. For some of the topics you may not know factual information; in these instances your impressions are sought. For any of the questions, if you prefer, you can address your response in relation to education in general, rather than to science education in particular.

Science education: What do you feel is most important for quality science education? What other factors do you believe are important for quality science education? In your experience what have been examples of quality science education?

Small class size: How many students should be enrolled in a science course? What happens when class size is small? What happens when class size is large?

Qualified instructors: What qualifications would you like for science teachers to have? What incentives should be provided to attract and retain qualified instructors? Are education, teaching experience, and participation in industry important?

Classroom facilities: Are the current science classroom facilities adequate? What classroom facilities would you ideally want to have?

Laboratory equipment: What equipment is needed in a science laboratory? How does the laboratory equipment now available compare to what is needed?

Industry support: How would you like business to support science education? If business should support science education, which companies would you like to make contributions to science education in the schools?

Security: What measures are necessary to assure that a school is safe? How should disruptive students be dealt with? How should violent students be dealt with?

Computers: How should computers be used in science classrooms? If they should be used, how many computers, and what peripheral equipment should each classroom have? What software would be useful?

Reading and writing: How should science be used to teach reading and writing? What reading and writing abilities do scientists need?

Hands-on experiments: How often should science students engage in hands-on experiments? Why are hands-on experiments preferable to demonstrations? What are some important hands-on experiments that students should perform?

Cafeteria: How does a school cafeteria support education? What level of quality food and what standard of service should a school cafeteria attain?

Social activities: How do social activities at a school support education? What types of social activities would you like for a school to have?

Sports: How do sports support education? What should be the academic requirements for students who participate in sports?

Other: Are there other issues that you think are important with regard to science education? In your experience, what have been examples of these issues?

Appendix F

REQUEST FOR PARTICIPATION

(Insert date here)

TO: (Insert name here)
FROM: Gary Wilkins
SUBJECT: Focus Group

Dear (insert name here),

I am currently writing my dissertation for my doctorate. As part of my research, I would like to request your participation in a focus group. I would like to know your opinions regarding education. I have about a dozen topics that I'd like to discuss, and I expect that the meeting would last up to ninety minutes. I will need to tape the meeting so that I can make a transcript. When I write my report you will remain anonymous.

Would you please attend a focus group meeting? I would like to hold the meeting at my classroom. The focus group would begin as close to 4 p.m. as possible on (Insert date here), and we will finish no later than 5:30 p.m. Refreshments will be provided. If you would like to attend, please give me a call. I respect your opinions, and I would value your contribution.

Thank you for your consideration,

Gary Wilkins
Student, Fielding Graduate Institute

(Insert date here)

TO: (Insert name here}

FROM: Gary Wilkins

SUBJECT: Interview

Dear (insert name here),

I am currently writing my dissertation for my doctorate. As part of my research, I would like to request an interview. I would like to know your opinions regarding education. I have about a dozen topics that I'd like to discuss, and I expect that the meeting would last up to sixty minutes. I will need to tape the meeting so that I can make a transcript. When I write my report you will remain anonymous.

Could I please interview you? I would like to conduct the interview at your office. I can interview you on a Monday through Thursday, beginning at 4 p.m. or later. I will be calling in a few days to request a date and time. I respect your opinions, and I would value your contribution.

Thank you for your consideration,

Gary Wilkins

Student, Fielding Graduate Institute

Appendix G: Focus Group Consent Form

The goal of the focus groups is to determine what teachers and community members believe is important to science education. Participants are asked to discuss twelve topics related to science education. Focus groups meetings are expected to take approximately ninety minutes.

Participants are science teachers and members of the school community. Participation is voluntary, and the refusal or withdrawal of a participant from the study will not constitute a penalty and their data will be removed and destroyed. To attain confidentiality I will only identify the subjects as teachers and community members. I will not disclose the names of the participants. Participants may develop slight anxiety as a result of the insight regarding educational factors that the research should create, if this occurs, they can be helped to find support. I will discuss with any subject any concerns that they may have. Participants could be benefited by improvements in science education that may occur as a result of this survey.

The survey is conducted as partial fulfillment of requirements for my Educational Doctorate (EdD) at the Fielding Graduate Institute. The data will be used for my dissertation and possibly for future books, articles, and academic publications. The Research Ethics Committee of the Fielding Graduate Institute retains access to signed informed consent forms. Please contact me with any questions.

Participants are requested to print and to sign on the lines below:

____

Name of participant (printed) Date

____

Signature of participant Date

Thank you for your support,

Gary Wilkins
Teacher, Small City High School
Doctoral Student, Fielding Graduate Institute
13041 Bullet Ave., Victorville, California 92392
(760) 241-5992, debngar@acninc.net

Mark-Scanlon Greene, PhD
Faculty Mentor, Fielding Graduate Institute
922 S. 150th Place, #B201, Burien, Washington 98148
(206) 439-8247, megreene@fielding.edu

Interview Consent Form

The goal of the interviews is to determine what experts believe is important to science education. Participants are asked to discuss twelve topics related to science education. Interviews are expected to take approximately sixty minutes.

Participants are science education experts. Participation is voluntary, and the refusal or withdrawal of a participant from the study will not constitute a penalty and their data will be removed and destroyed. To attain confidentiality I will only identify the subjects as science education experts. I will not disclose the names of the participants. Participants may develop slight anxiety as a result of the insight regarding educational factors that the research should create, if this occurs, they can be helped to find support. I will discuss with any subject any concerns that they may have. Participants could be benefited by improvements in science education that may occur as a result of this survey.

The survey is conducted as partial fulfillment of requirements for my Educational Doctorate (EdD) at the Fielding Graduate Institute. The data will be used for my dissertation and possibly for future books, articles, and academic publications. The Research Ethics Committee of the Fielding Graduate Institute retains access to signed informed consent forms. Please contact me with any questions.

Participants are requested to print and to sign on the lines below:

____

Name of participant (printed) Date

____

Signature of participant Date

Thank you for your support,

Gary Wilkins
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Doctoral Student, Fielding Graduate Institute
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