Alignment of the NASA Explorer School Model with Models for School Improvement and Reform
Paper Prepared for the Committee for the Evaluation and Review of NASA's Pre-College Education Program
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Introduction Based on the premise that one component of NASA's pre-college education program is intended to support and enact school reform, the Committee for the Evaluation and Review of NASA's Pre-College Education Program requested an analysis of how the NASA Explorer School (NES) Model aligns with other national models of school-wide improvement and reform. The purpose and focus of this paper is to summarize key elements of major school improvement and reform models as well as specific content reform models from the literature, and to analyze the extent to which there is alignment between these models and the NES model.

NASA Explorer School Model
The NASA Explorer School Model is a three-year partnership connecting NASA resources (NASA headquarters, 10 Field Centers and local, state and national partners) with selected NASA Explorer Schools. The program establishes teams of educators and administrators at each school who develop action plans and implement Explorer School interventions tied to local needs. The model has now involved 200 schools that serve a high number of poor and minority students from all 50 states, the District of Columbia and Puerto Rico.
NES has three major goals:

- To provide all students the opportunity to explore science, technology, engineering and mathematics (STEM) topics in a variety of NASA contexts, using advanced technologies to increase student interest, participation, knowledge about careers, and ability to apply STEM knowledge and ability.

- To provide educators with sustained professional development, unique STEM-based teaching and collaborative tools, digital content resources, and compelling NASA contextual-based teaching applications that align with national standards for targeted content areas.

- Build strong family involvement within NASA Explorer Schools.

Theory of Change of NASA Explorer Schools Model
The theory of change for this program as indicated in the program's logic model is that through involvement with NASA programs, products and services, teachers will increase their ability to teach STEM topics, students' interest and achievement in STEM will be enhanced, and families will increase their involvement in STEM activities in school and the home (Davis, 2006). To enact this change, NES engage in the following program elements:

- *Teacher professional development.* Over the three years of engagement as an Explorer School, faculty participate in three summer professional development meetings: an

orientation, a content workshop and a sustainability workshop. In addition, onsite professional development is offered to teachers on a voluntary basis during the school year. The orientation and sustainability workshops are focused on planning and maintaining Explorer School activities, whereas the onsite sessions and content workshop are focused on building teachers' knowledge in STEM topics.

- *Student learning opportunities based on unique NASA resources.* Students participate in an annual student symposium and see and learn about NASA products and programs through videoconferencing and the Digital Learning Network.

- *Parent involvement.* Families are invited to participate in Explorer School events such as family science nights, star gazing parties, and astronaut events.

Based on the theory of change, the NES model expects to produce the following outcomes:
- Outcomes for Teachers and Schools
    - Administrator support to promote effective STEM teaching and learning;
    - Enhance teachers' understanding of STEM topics and careers;
    - Enhance teachers' knowledge of inquiry; and
    - Increase use of NASA technology in schools.

- Outcomes for Students and Families
    - Increase student STEM knowledge;
    - Increase students' interest in pursuing STEM careers;
    - Provide opportunities for students to apply STEM concepts; and
    - Increase family involvement in STEM activities.

Characteristics of School Reform Models
This section discusses the key elements of whole school improvement models and summarizes the characteristics of improved schools documented in school improvement literature. It then presents a set of common elements found in school improvement models and effective schools. These elements are then compared with the design elements found in the NASA Explorer School program.

School reform models and systemic approaches to improving student outcomes have been available to schools for well over 30 years. Beginning in the 1970s, the Effective Schools movement (Edmonds, 1979; Lezotte, 1989) advocated for fundamental change in schools to ensure that all students receive a quality, basic education. These reformers introduced a set of essential elements for all schools to enhance learning. The elements included establishing a safe and orderly environment, a focus on basic education, providing directive leadership, setting high expectations for all students, and creating a positive school climate where parents are welcomed and engaged. At this time, many poor urban districts took their first steps toward reform. They worked on creating safe and orderly environments by creating physical plants more conducive to learning and adopting consistent policies for discipline. Greater attention was paid to communicating with parents and helping them to become genuine members of the school community. However, while these initiatives resulted in some progress, too few schools made improvements focused on teaching and learning and raising

expectations for all student and many of the classroom focused initiatives that were implemented relied upon memorization and drill and practice approaches to learning, especially in the most disadvantaged schools.

Building on the Effective Schools movement, other school reform models were developed to address the problem of mediocre and inequitable educational practices in the U.S. Approaches to school reform including the Coalition of Essential Schools, Success for All, Accelerated Schools Model, School Development Model and others, introduced new ideas about how students learn, such as through cooperative learning and engagement with phenomenon, and stressed the importance of standards and assessment. Other models have continued to emerged in the last decade or so, including the New American Schools models, providing a wide range of school design and reform options.

Elements of Whole-School Reform Models. There are many commonalities shared by the whole-school reform models. Most were developed by experienced researchers and educators and are based on available research on how students learn, on knowledge of effective school organization and leadership, and a commitment to making fundamental change in the operating structures and outcomes of schools. As suggested by the Rand (2002) study of the New American Schools model, educational reform models must have two components: 1) a *theory of learning* that lays out the model's assumptions about how learning occurs, instructional approaches and student performance and 2) a *theory of action* that defines the conditions necessary to bring about reform. As one considers what essential elements are needed for whole-school reform, these existing models provide important examples. Each has developed its theory of learning and theory of action that can potentially inform others designing reform efforts. However, it is important to keep in mind that there has been little rigorous research to indicate the effects of the various models and to validate their contribution to positive student outcomes. More research is needed to understand the factors that contribute to improved student learning and other positive school outcomes from these models. To identify the key elements of whole-school reform models for this paper, only models reportedly found to have some (sometimes limited) evidence of outcomes were examined.

The American Institutes for Research (1999) conducted a review of existing research studies for 18 middle and high school comprehensive school reform models funded by the U.S. Department of Education for elementary, middle and high school. This review illustrates the lack of available research evidence on these models. Just 42 out of 197 studies were found to have acceptably rigorous research designs that included student achievement outcomes. Other studies with less rigorous designs were included in the review. Five programs were found to have moderate evidence of positive effects on student achievement. These are: America's Choice, First Things First, Success for All-Middle Grades, School Development Program, and Talent Development High School. The percentage of models in this analysis that were able to show some success was 27.7%. The percent of programs that were successful in showing some gains among the New American Schools models, were somewhat better with 81 out of 163 schools or 50% making gains in mathematics as compared with the district and 76 schools (47%) with gains in reading as compared with the district (Rand, 2002).

In a review of 22 elementary school models, AIR (1999) reported moderately strong evidence of positive student impact for two programs (9%) including Success for All and Direct Instruction. Seven (32%) reportedly had moderate evidence of positive student impact, including Accelerated Schools PLUS, America's Choice School Design, Core Knowledge, Literacy Collaborative, National Writing Project, School Development Program, and School Renaissance.

Table 1 (see page 5) provides background information on the major features, results and costs of several of these programs. As detailed in Table 1, the programs have several main features and mechanisms to support implementation. Some common elements of these include:

- Focus on school-wide changes in practices, beliefs, and operation;
- Use of standards or research-based curriculum and instruction;
- Alignment among standards, curriculum and assessments;
- Meaningful involvement of families in education;
- Faculty buy-in and commitment;
- School based implementation teams to lead change efforts;
- Leadership: policies and supports to guide implementation; and
- Professional development and ongoing coaching/collaboration.

Similar program elements are included in the designs of the New American School's reform models. Six areas of implementation were measured over time to assess the extent to which key elements were in place and how implementation changed over a three-year period. The elements of New American School models are:

- Parents and the community are involved in the educational program;
- Student assessments are linked to academic standards;
- Teachers monitor student learning progress with individualized learning programs;
- Student grouping is flexible in terms of multi-age groupings;
- Teachers are continual learners, engaging in professional development, collaboration, and common planning; and
- Students know their performance expectations and track their own progress (Berends, Bodilly & Kirby, 2002, p. 191).

A study of the New American Schools comprehensive school reform model reports that, "A critical assumption underlying these designs is that coherent, focused and sustained implementation of key design components (including professional development, curriculum and instructional materials, content and performance standards, assessments, organization and governance, and parent and community involvement) will eventually change school and classroom learning environments and thereby students' academic outcomes…." p. 5-6 (Rand, 2002). The study identifies factors that affect implementation and outcomes, include:

- The design (how coherent, comprehensive);
- Assistance offered to ensure implementation;

- Teacher "buy in"; schools' capability to take on and use reform (its leadership capacity, teacher capability, history of past reform efforts); and
- Contextual factors such as district infrastructure, support and incentives, and accountability policies (Berends, Bodilly & Kirby, 2002).

Newmann et al describe school capacity as an additional factor critical to successful reform. While school reform models may offer a sound set of interventions to a school, the school's capacity will have an impact on the intervention's success. They define school capacity as the *interaction* of five key areas: Teachers' knowledge, skills, and dispositions; professional community; program coherence; technical resources; and principal leadership (Newmann, King & Young, 2001). The study of the New American Schools models found principal leadership to be a critical contributor to the level of implementation achieved in reform sites (Rand, 2002).

Table 1: Summary of School Reform Models (Compiled from The Catalog of School Reform Models, Northwest Regional Education Laboratory, 2004)

Model	Main Features	Evaluation Results	Cost
Accelerated Schools	Curriculum providing gifted-and-talented instruction for all students Participatory process for whole-school transformation Three guiding principles: 1. Unity of purpose 2. Empowerment plus responsibility 3. Building on strengths	A five-year study of eight Accelerated Schools found little or no impact on test scores during the first three years of implementation (when the focus was on reforming school structure and governance), then a gradual increase in scores during the fourth and fifth years (when substantial changes in curriculum and instruction were taking place). Average scores in the fifth year exceeded predicted scores by seven percentile points in reading and eight in mathematics, a statistically significant amount (Bloom et al., 2001.)	$45,000 per year for a Basic Partnership Agreement with a minimum three-year commitment Costs for two days of release time for the entire teaching staff and the equivalent of four days of additional training during the first year Weekly meeting time for faculty (about 36 hours per year) 25% of the full-time salary and benefits of the coach
America's Choice	Implement standards and assessments Align instructional systems Focus on literacy and mathematics Use high-performance leadership, management, and	An external longitudinal evaluation of three jurisdictions implementing the America's Choice School Design (Plainfield, New Jersey; Duval County, Florida; and Rochester, New York) revealed a clear difference between America's Choice schools and comparison schools in the performance of students	$70,000 per year for elementary schools (about 700 students) $75,000 per year for middle schools (1,000 students) $85,000 per year for high schools (1,000 students)

	organization Build professional learning communities	on state assessments. (Supovitz & May, 2003; Supovitz et al, 2001)	
Core Knowledge	Sequential program of specific topics for each grade in all subjects Structured program to build vocabulary and skills to improve literacy	A three-year study conducted by independent researchers at Johns Hopkins University compared student achievement at four Core Knowledge schools and four control schools (Stringfield, Datnow, Borman, & Rachuba, 1999). They found that the Core Knowledge and control cohorts made similar gains in reading and mathematics on the CTBS and other norm-referenced tests. However, when Core Knowledge schools where less than 50 percent of teachers were implementing the sequence were excluded, the performance of the Core Knowledge students at the remaining schools was higher than that of control students in both subjects.	For a school with 25 teachers and 500 students, estimated costs are: Year 1: $45,000 Year 2: $37,000 Year 3: $37,000 School must also: Purchase the Pearson Learning/Core Knowledge history and geography textbooks (grades K-6) Budget a minimum of $1,000 per teacher for Core Knowledge materials per year Allocate a minimum of $8 per student in grades 1-5 for administration and scoring of TASA's Core Knowledge Curriculum Referenced Tests Purchase the Baltimore Curriculum Project lesson plans
First Things First	Seven research-based critical elements Small Learning Communities (SLCs) at all levels, with themes at middle and high school levels Family Advocate System Instructional improvement focus on active engagement of students, alignment of what is taught with standards, and high-	An internal research team studied the impact of First Things First on the Kansas City, Kansas, School District in 2003 (IRRE, 2003) using state standardized math and reading tests over three years, from 2001 through 2003. Students are tested in grades 5, 8, and 11 for reading and grades 4, 7, and 10 for mathematics. Three-year trends indicate statistically significant improvement in the number of students functioning at the "Proficient or Above" level on state math and reading exams.	Planning Year: $150,000 Implementation Year One: $80,000 Implementation Year Two and Up: $50,000/year Stipends and release time for SLC coordinators ($500 during planning year, $2,000 during implementation years)

	stakes assessments and rigor	These district trends are more positive than statewide trends, and demonstrate a statistically significant narrowing of the economic and ethnicity achievement gaps in math and reading.	
School Development Program	Nine element design (Haynes et al 1996): Three teams: 1. School planning and management team 2. Student and staff support team 3. Parent team Three operations: 4. Comprehensive plan for staff development 5. Monitoring 6. Assessment Three guiding principles: 7. No-fault 8. Consensus 9. Collaboration Other features: Understanding and application of principles of child and adolescent development Establishment of healthy relationships among all stakeholders	Cook, Murphy, and Hunt (2000) reported on SDP's effectiveness in 10 Chicago schools from 1992 to 1997. They randomly selected nine no-treatment comparison schools for their study and evaluated normal curve equivalents (NCE) on the ITBS reading and math tests. By the last two years of study, SDP schools had gained about three NCE points more than the comparison schools in both reading and math. Another study (Millsap et al., 2000) suggests that higher-implementing SDP schools in Detroit had a greater impact on reading scores relative to comparison schools than lower-implementing schools.	The School Development Program contracts with districts for the participation of four or more schools. A contract includes: Administration costs ($5,000 for up to five schools per district, and $1,000 for each additional school) Training tuition costs ($1,000 per person per weeklong session) Consultation costs ($1,200 per day of site visitation, plus expenses) Release time and travel expenses for trips to Yale University and release time for on-site visits Salary for a district Comer coordinator
Success For All	Research-based curricula in four subjects (reading, math, science, social studies) Integrated science and social studies program Cooperative learning	Four pilot Success for All/Roots & Wings schools in Maryland demonstrated substantially greater gains in third and fifth grade on the Maryland School Performance Assessment Program (MSPAP) in all six subjects tested (reading, writing, language, math, science, and social studies)	$75,000 to $80,000 per year for three years for a school of 500 students (preK-5) Costs of a full-time facilitator Staff time for attending training sessions

	One-to-one tutoring Family support team	than schools statewide. Over the five-year period, model schools showed greater gains than schools statewide on every measure except fifth-grade language (Slavin & Madden, 2000). In a study of restructuring schools in Memphis, researchers reported that schools that adopted school reform models, including Success for All/Roots & Wings, demonstrated greater gains on the Tennessee Value-Added Assessment System than non-restructuring schools. Success for All/Roots & Wings was one of two models overall that showed statistically significant effects compared to non-restructuring schools (Ross et al., 2001).	
Talent Development High School	9th-grade success academy Career academies for grades 10-12 Core curriculum in a four-period day Transition courses in math and reading Freshman seminar Alternative after-hours program	1998 case study of TDHS's Patterson High School in Baltimore, conducted by the model developers, examined the percentage of ninth grade students passing the Maryland state functional examination. The percentage of students passing rose from 28 percent (1994) to 56 percent (1997) in mathematics, and from 55 percent (1994) to 57 percent (1997) percent in reading. On writing exams, the percentage of students passing fell one percentage point during that period. The TDHS math and reading pass rates in 1997 were higher than the district's mean pass rates (34 percent district-wide in math and 52 percent in reading). On the state's school performance index, which is based on attendance,	Annual fee of $10,000 for administering feedback and maintaining contact with school Between $10,000 and $50,000 for technical assistance sessions Fund the full-time program facilitator (or 0.5 FTE if two schools in a district are implementing) This typically costs between $60,000 and $80,000. Fund one to two teachers from the local district to serve as curriculum coaches. Teacher stipend for up to 25 hours of professional development Curriculum Materials: $35,700 the first year and

		retention, and test scores, Patterson rose seven percentage points from 1995-97, while the mean index for the district dropped half a point (McPartland, Balfanz, Jordan, & Legters, 1998).	$17,000 the second year Student Survey: $2.55 per student.

Content Specific Reform Models

In addition to the above examples of whole-school reform models, the U.S. Department of Education also supported Skill and Content Based Reform Models in specific subject areas such as math, science and reading. These programs are smaller in scope than the whole-school reform models and focus on reforming a particular subject. At the center of these programs is usually a specified curriculum or clearly defined instructional program that is adopted by the school. The curriculum becomes the focus of the intervention and professional development is provided to develop teachers' understanding of the new program and support changes in instructional practice.

Skill and Content Based Reform Models in Reading Language Arts
- Breakthrough to Literacy (K-2)
- National Writing Project (K-16)
- Reading Recovery
- Junior Great Books
- Strategic Teaching and Reading Project

Skill and Content Based Reform Models: Mathematics
- Comprehensive School Mathematics Program (k-6)
- Connected Mathematics Program (6-8)
- Interactive Mathematics Program
- University of Chicago School Mathematics Project

Skill and Content Based Reform Models: Science
- Developmental Approaches in Science, Health and Technology (K-6)
- Foundational Approaches in Science Teaching (Middle School)
- GALAXY Classroom Science (K-5)

Below are brief descriptions, background on development, cost information and evidence of success for several Skill and Content Based Models.

Reading Recovery
Reading Recovery is a short-term intervention of one-to-one tutoring for low-achieving first graders. It was developed by Marie Clay in the late 1970's in New Zealand to improve reading outcomes for failing students based on research on learning with low-achieving students and classroom interventions found to improve student results. Professional development is an essential part of Reading Recovery. It includes an academic year of

graduate-level study and continues in subsequent years. With the support of the teacher leader, Reading Recovery teachers develop observational skills and a repertoire of intervention procedures tailored to meet the individual needs of at-risk students. There are start-up and ongoing costs for Reading Recovery. Start up costs include selecting and training a teacher leader, paying tuition for training, building costs, including a one way mirror and sound system for teacher training. A typical school with one Reading Recovery teacher can serve 4-5 students per semester. Ongoing expenses include costs per child that range between $2,300 and $3,500.

According to a review of research on Reading Recovery, by the What Works Clearinghouse (U.S, Department of Education website, nd) the program was found to have positive effects on students' alphabetic skills and reading achievement outcomes. The program was found to have potentially positive effects on comprehension and fluency.

Connected Mathematics Program
The Connected Mathematics Project (CMP) is a problem-centered mathematics curriculum designed for all students in grades 6–8. Each grade level of the curriculum is a full-year program of instruction in numbers, algebra, geometry/measurement, probability, and statistics. The program makes connections within mathematics, between mathematics and other subject areas, and to the real world. Five mathematics educators and mathematicians from Michigan State University, University of North Carolina and University of Maryland developed CMP. The developers state on their website that the program was developed based on their "knowledge of theory and research; their imaginations and personal teaching and learning experiences; advice from teachers, mathematicians, teacher educators, curriculum developers, and mathematics education researchers; and advice from teachers and students who used pilot and field-test versions of the materials." The professional development program provides in-depth learning in three areas: mathematics content knowledge; teaching and learning; and assessment.

The cost of implementing the program is $8.47 per student and $20.97 per teacher unit. Costs for professional development vary. The What Works Clearinghouse (WWC) reviewed twenty-two studies on the Connected Mathematics Project. Three of these studies met evidence standards with reservations; the remaining studies did not meet WWC evidence screens. Based on these three studies, the WWC found the program to have "mixed" effects on math achievement (Ridgway et al, 2002).

Foundational Approaches in Science Teaching (FAST)
FAST is a laboratory- and field-oriented science program designed for use with middle school students. The program was developed at the University of Hawaii by science educators and scientists and sequenced to address differences in learning styles and to develop thinking skills. Students study three strands concurrently: physical science, ecology and relational study. Content has been aligned to the National Science Education Standards. Teachers must attend a pre-implementation teacher institute prior to using the program at each grade level. In addition, ongoing networking and problem solving assistance is provided to teachers as they implement the program. Cost for teacher institutes ranges from $630-$840 for 5 day course and approximately $2,000 per classroom for the student books and materials.

National LASER K-8 Science Education Strategic Planning Institutes
Through this program, school district leadership teams participate in a 5 1/2 day program of workshops and discussion groups to learn how to lead and sustain local science education reform efforts. Teams explore research on learning, examine research-based science curriculum, learn the program's five elements of reform: curriculum, professional development, materials support, assessment and administrative and community support. Teams develop a strategic plan to lead reform efforts in their schools. The cost of the institute is $6,000 per five person team and travel expenses. Teams initiate individual reform efforts in their sites which can include curriculum adoption, development of materials management systems, new assessments in science, and professional development. The costs of these initiatives vary.

These content specific programs share some similarities with the NASA Explorer School model. For example, the NSRC Strategic Planning Institute creates and supports a school-based team to plan and lead science reform efforts. All of the programs offer professional development for teachers. Where they vary is that these models offer research-based curriculum to be implemented in the school site and ties teacher professional development directly to implementing the specific new or enhanced instructional program.

Common Elements of School Improvement Approaches
In addition to considering how the Explorer Schools Model reflects elements of comprehensive school reform models and curriculum focused models, this paper also examines how the NES model aligns with other common elements of school improvement suggested in the literature. One set of themes comes from a synthesis of research on the characteristics of improved school districts (Shannon & Bylsma, 2004). Based on a meta-analysis of 80 studies, this report identified four overall themes from research on the characteristics of improved school districts:

- **Effective Leadership**, including a focus on all students learning, dynamic distributed leadership, sustained improvement efforts.

- **Quality Teaching and Learning**: high expectation for adults, aligned curriculum and assessment, coordinated and embedded professional development, quality classroom instruction.

- **System for System-wide Improvement**: effective use of data, strategic resource allocation, policy/program coherence.

- **Clear and Collaborative Relationships**: building professional culture and collaboration, schools and districts roles/relations.

Effective Leadership. Leadership has been identified as a significant factor in student learning. It can account for approximately 25% of school effects (Hallinger & Heck, 1996). Leadership is essential for improving schools—as Leithwood et al write: "…demonstrated effects of successful leadership are considerably greater in schools that are in more difficult

circumstances. Indeed there are virtually no documented instances of troubled schools being turned around without intervention by a powerful leader." (p. 3) Most whole school reform models include a focus on building the knowledge and skills of leaders to perform leadership actions that contribute to school success. Waters, Marzano & McNulty (2003) identified 21 specific responsibilities of leaders that influence learning. Building such leadership responsibilities in school reform sites is a major component of many school improvement models. School level leadership that impacts student learning includes "identifying school mission and goals, culture, teachers' participation in decision making, and relationships with parents and the wider community of potentially powerful determinants of student learning" (Leithwood et al, 2004 p 11).

Several instructional leadership models are used within school improvement programs. Hallinger focuses on building three leadership dimensions: Defining the school mission, managing the instructional program, and promoting a positive learning climate. Other leadership models see for example, Andrews & Sodder (1987) and Duke (1987), focus on developing the knowledge and skills of effective school leadership. According to Leithwood et al: "The basics of successful leadership includes three sets of practices:
1) Setting direction: including building a vision and shared organizational purposes, developing buy-in to group goals and setting high expectations for performance, monitoring performance and progress toward goals, promoting effective communication;
2) Developing people, including intellectual stimulation, "providing individualized support and providing appropriate models of best practice and beliefs considered fundamental to the organization." and
3) Redesigning the organization. Practices include: strengthening the school and district cultures, modifying organizational structures and building collaborative processes. (Leithwood et al p 6-7).

Quality Teaching and Learning. In improved schools teachers implement quality curriculum aligned with challenging learning goals designed to deepen student understanding over time. Reform models provide a coherent set of instructional materials that meet this requirement, not just disjointed activities. In a study of improved school districts in Ohio curriculum alignment was identified as the strongest factor contributing to improved student achievement (Kercheval & Newbill, 2002). Along with quality curriculum, the improvement of instructional practice is a central goal of most school improvement programs. As new practices are introduced, practiced and mastered, change leaders monitor implementation, provide feedback and support and engage teachers in assessing impact on students.

Professional development plays a leading role in supporting full implementation of new curriculum materials and transforming instructional practice. There is a growing recognition that there are no "one size fits all" models for professional development. Rather, a good program is designed to address the particular needs and to fit into the context in which it will be implemented. As such, professional development may look very different from place to place. Yet, there are common features that have been shown to be necessary for effective teacher learning. These features must be carefully considered as one designs and implements professional development programs. Well-designed programs provide the following:

- Teacher learning is tied directly to clear and challenging goals for student learning;
- Program is designed to allow adequate time, follow up and continuity;
- Professional development is coherent with district programs and policies;
- Learning focuses on the subject matter and how to teach it;
- Design includes active and engaging activities based on how people learn;
- Teachers engage in critical reflection on practice; and
- There is ongoing evaluation of results (Garet et al 2001, Kennedy, 1999, Loucks-Horsley et al, 2003; Bransford, Brown & Cocking, 1999; Weiss & Pasley, 2006).

System for System-wide Improvement.
Another element of effective school practice is the ongoing use of student and other data to inform education policy and practice. Schools and districts are increasingly using ongoing formative assessment of students to enhance instruction and intervene when students do not learn. School improvement models create system-wide strategies for collecting and using data in this way. System-wide strategies also focus on ensuring that the school improvement efforts are coherent and aligned with district and school policy (Corcoran & Lawrence, 2003). They establish clear expectations for program outcomes, maintain a focus on agreed upon goals and sustain improvement efforts over time. They also create realistic plans, including allocating appropriate resources to meet the stated school improvement goals.

Clear and Collaborative Relationships. Improved schools have built a professional culture characterized by ongoing professional growth and commitment to student learning. Teachers have a sense of responsibility to their colleagues and students. Districts that made significant improvements in science and mathematics learning were ones that had build a trusting culture among the staff (Spillane & Thompson, 1997).

Many of the comprehensive school reform models focus on building professional culture or professional learning communities within schools. In a synthesis of research on schools with professional culture and teacher collaboration, Hord (1997) identified many positive attributes. Among them she found:

- Increased commitment to the mission and goals of the school and increased vigor in working to strengthen the mission;
- Shared responsibility for the total development of students and collective responsibility for students' success;
- Reduction of isolation of teachers;
- Increased meaning and understanding of the content that teachers teach and the roles that they play in helping all students achieve expectations;
- More satisfaction and higher morale, and lower rates of absenteeism; and
- Higher likelihood of undertaking fundamental, systemic change.

For students suggested benefits are:
- Lower rates of absenteeism;
- Decreased dropout rate and fewer classes "cut";

- Larger academic gains in math, science, history, and reading; and
- Smaller achievement gaps between students from different backgrounds (Hord, 1997).

Family Involvement. Building on the common elements above, there is evidence from research and school improvement practice of the need to involve parents and families in their children's education. The U.S. Department of Education guidelines for schools implementing comprehensive school reform directs schools to select programs that provide for "meaningful parent and community involvement in planning, implementing and evaluating school improvement activities." A study of the impact of parent involvement on the reading and mathematics achievement of Title I students in second through eighth grade, found that parent involvement was a significant factor influencing students' academic success in reading and mathematics (Shaver & Walls, 1998). Wang and Wildman (1995) analyzed data from the 1988 Longitudinal Study of American Youth to determine the effect of family commitment in education on student achievement in science among 3,000 seventh grade students over a period of four years. The analysis suggests that science educators help parents promote achievement by encouraging them to express confidence in their children's ability; encourage children to do their homework themselves; take time to talk with children about school activities; and encourage their children's interest in science.

Costs of School Reform

Cost is another factor to consider regarding the alignment of the NES model with other school reform initiatives. Explorer Schools are funded at just $17,500 to cover activities from orientation through sustainability (approximately three years). As detailed in Table 1, comprehensive school reform models require considerable more resources than those provided for Explorer Schools. The funding available for NES is more in line with the costs of specific content focused models outlined above.

The US Department of education funding from the Comprehensive School Reform program provided individual schools with funding up to $50,000. These grant typically covered the cost of external assistance and acquiring the curriculum materials associated with the model. In addition, substantial local funding was also used to support teacher time for professional development, other required materials and technology. First-year costs differ greatly from program to program, but can range anywhere from $98,000 for ATLAS Communities to as high as $588,000 for Co-NECT, a program of Bolt Beranek and Newman (American Institutes for Research, 1999).

The state of California's system for funding school wide improvement for its failing schools has up until this year, provided from $200-$400 per students for two to three years. This year in recognition of the true costs of school improvement, the state is providing $500 per student for elementary schools, $900 per student for middle schools and $1000 per student for high schools each year for a period of seven years. Under this formula, schools will receive far more funding on average than comprehensive school reform districts received.

Comparison of the Explorer School Model with Elements of School Reform Models

One major consideration in the comparison of the NES model with whole school reform models is the central purpose of these different interventions. Comprehensive school reform

models are aimed primarily at making substantial (top to bottom) improvements and changes in schools. The interventions range from completely overhauling curriculum, changing school schedules and student assignments, and shifting beliefs about teaching and learning and about which students can succeed. The basic purpose of the NASA Explorer Schools is not quite so expansive. As outlined earlier in this paper, the NES model aims to add new knowledge and skills for teachers and engage students and their families in science learning based on services, programs and products unique to NASA. While many lessons can be taken from the literature and the designs of comprehensive school models, one must keep in mind the fundamental differences in these purposes. A program designed to address one purpose may not necessarily include all the elements of a program designed for a different purpose. NES may more closely resemble specific content focused programs such as the ones outlined in this paper.

Common Elements. Looking across the reform models, their program elements are focused in two main areas. The first is a set that defines the innovation itself—e.g., clearly defined and specified curriculum, use of assessment materials, and professional development designs. The second is a set related to how the developers believe the model should be implemented and supported to attain the desired results (the change model or theory of action), e.g., processes for developing faculty buy-in, administrator leadership, use of external technical assistance. The two sets of common elements are listed and described in the tables below. The left hand column describes how the element is designed in many reform models. The right hand column describes the claims of how the NES model includes or addresses the elements.

Table 2: Common Features of the Innovations

School Reform Models	NASA Explorer School Model
Use of and Alignment of Standards-based Curriculum, Instruction and Assessment Content specific reform models feature specific instructional approaches and materials and/or implement a program specific curriculum. Whole-school reform models call for the adoption and use of a rigorous standards-based curriculum or provide a specific curriculum as part of the model. Specific models include tools and methods for student assessments and introduce the practice of formative assessment in the classroom.	The NES model does not include the use of specified SMET curriculum. Teachers may opt to attend professional development that introduces activities based on NASA resources and promotes the use of inquiry, but there are not specific instructional and assessment strategies or curriculum to adopt. NASA provides Educator Guides on specific mission content for use in lesson planning.
Professional Development and Teacher Learning Communities Whole-school reform models promote teacher learning that is ongoing, and maintains a sustained focused on implementing the practices defined by the model. Content specific reform models are centered in teaching how to use specific curriculum and instructional	The NES model offers teachers the opportunity to attend conferences and content workshops on NASA related topics of interest to them. The model encourages teachers to return to their district and mentor others and provide local inservice. Aerospace Education Specialists provide professional development focused on learning about NASA resources.

materials and supporting teachers in their use through ongoing networks and teacher learning communities.	
Focus on Student Learning The whole school and content specific reform models are focused on ensuring learning and helping students meet standards. Several improvement models provide intensive courses (in literacy or mathematics) for students who are below grade level and others provide challenging content to prepare students for Advanced Placement coursework in high school. Many whole-school reform models institute student assessment systems to track student learning and progress and use data to intervene when students do not learn.	NES programs offer enrichment opportunities that may be connected to student learning standards, depending on the local site. Students can access subject matter experts through the Digital Learning Network and design and implement research. There is no indication in NES program materials that the program engages in intervention for underperforming students or assessment to track student learning and progress in NES related programs.
Family Involvement Parents are included in the planning, implementation and assessment of whole-school reform models. Parents may serve on advisory or action teams for programs.	The NES model identifies and trains a family coordinator to facilitate Family Nights to raise awareness and interest in science. The model encourages schools to provide ongoing family events on SMET topics and to involve community leaders. NASA's Science Engineering Mathematics and Aerospace Academy (SEMAA) provide family involvement resources for parents of K-12 minority students who are underrepresented in STEM careers to promote interest and awareness of opportunities.
Benchmarks for Student Achievement Programs establish specific goals for student learning gains such as numbers of students reaching proficiency and maintaining grade level performance or above.	There is no indication in the NES program materials reviewed that the program sets specific benchmarks for student learning gains in SMET. Goals include to "increase students' STEM knowledge" with no specific benchmarks identified.
Leadership Development Leaders are engaged in learning how to support school reform. Principals and other leaders participate in training and play a key role in introducing and sustaining the reform model. In the case of specific content focused models such as mathematics or literacy programs, leaders communicate with parents and the community about the goals of the program and the implementation plan. They support teachers to attend professional development and	The NES model establishes an NES action team involving the school principal and teachers. The team has leadership training and develops a plan for using NES resources in the school.

provide time for planning and collaboration.	
Resource Provision Curriculum and ancillary materials that support the project are provided.	Then NES model establishes a NASA resource library to provide access to resources.

Table 3: Elements of Change Process

School Reform Models	NASA Explorer School Model
Clearly Defined Program Program is clearly defined and communicated to all. There is a definition of what will be implemented and what changes in practice are expected. In the New American Schools models higher levels of implementation were found to be related to clear communication with and strong assistance from the design teams (Rand, p. 8).	Orientation phase includes clarification of the program, partners' roles, NES goals, student achievement goals are based on local data.
Data Use Data are collected and shared widely to assess how well the program is being implemented and its impact on students and teachers.	NES teams conduct student needs assessment, technology infrastructure assessment and identify existing support activities in the school to inform planning. Teachers are surveyed to gather input into their interests in the programs. Evaluation data on activities conducted is collected and used to update implementation plans. Impact data has not been collected.
Leadership Leaders commit to the reform and provide both pressure and support to plan and guide implementation. School based implementation team leads efforts.	NES representatives meet with administrators to clarifying their role in promoting family events, integrating NASA into the curriculum, making systemic changes in scheduling and curriculum, and organizing professional development.
Buy-in/Commitment Program makes a strong case for the program to the entire community. Teacher buy-in is a requirement for moving ahead with implementation.	Program calls for communication with full faculty to introduce NES as a whole school reform effort and create awareness of the implementation plan and available resources.
Attention to Sustainability Whole-school and specific content reform models call for the use of data to guide implementation, budgeting of needed resources such as the costs of student materials, planning of follow up and ongoing teacher professional development to strengthen the use of the model in the schools.	NES model provides a sustainability conference in which school teams consider how to continue their use of NASA resources and seek grants to support the program in the future.

Conclusion

While the NASA Explorer School program has some of the elements of school reform models such as its use of a school-based leadership/action team to guide the project, the involvement of families in the school community, and building local buy-in, it does not share many other elements of comprehensive whole-school reform. The first three elements of reform models listed in Table 2 are the essential ingredients that define what the model or innovation is. These elements are missing or not fully developed in the NES model.

The NES model is more centered on enhancing or enriching students' interest and excitement about SMET subjects by introducing students to the world of science, technology and aerospace engineering than on promoting whole-school reform. Its program components do not aim to overhaul curriculum or make structural change in school operation and design as school reform models do. Through family programs, the NES model encourages parents to nurture children's interest in SMET study and see science, technology and engineering as viable career options for the future. Teacher professional development helps teachers use NASA specific resources to enrich their teaching, such as by using inquiry or engaging in scientific research, rather than installing a comprehensive science, mathematics, or technology program in the school. These are important ways to encourage students, especially students from disadvantaged backgrounds, to develop their interest in the sciences, but are not necessarily leading to whole-school reform.

The NES model brings resources to schools and serves the purpose of developing a school's identity as a science-rich environment. Students gain exposure to NASA missions, projects and resources and the world of science. Rather than trying to be a whole-school reform model, NES can clarify it purpose and expectations as a program that is uniquely positioned to develop interest and enthusiasm for science teaching and learning and support schools to access cutting edge resources that may be integrated with and enrich their science program.

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