A Comparison of the Minds•On Physics Approach with the NRC's National Science Education Standards

pg.	NRC Standards* say ...	MOP replies ...
20	Science is for all students.	We believe that everyone can learn physics, especially if you give students many different ways to succeed.
20	Learning is an active process.	MOP is activity-based and engages the minds of students. MOP is rooted in constructivist epistemology, and we encourage teachers to use collaborative learning.
21	School science reflects the intellectual and cultural tradition that characterize the practice of contemporary science.	As we state in the first sentence of our preface to students: "The materials in this booklet are designed to get you *thinking about* and *doing* physics—in a way that is a lot closer to the way professional scientists think about and do science."
21	Improving science education is part of systemic education reform.	We agree.
30	Teachers should develop a framework of year-long and short-term goals for students.	(not applicable)
30	Teachers should select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.	We define a curriculum to be the materials plus the ways in which a teacher actually uses them. We know that materials alone are not sufficient, because teachers need to be able to adapt and use them effectively. We have invested much time in helping teachers learn how to do this. The *Instructional Aids for Teachers* are intended to help teachers design lessons to best address their students' needs.

* all excerpts and page numbers are taken from: National Research Council (1996). National Science Education Standards. Washington, DC: National Academy Press.

pg.	NRC Standards say ...	MOP replies ...
31	Teachers should select teaching and assessment strategies that support the development of student understanding and nurture a community of science learners.	In fact, assessments can be learning experiences for students. Also, because assessments drive curriculum, in order to successfully shift students attention, assessments must be modified as well. In our *Instructional Aids*, we provide examples that teachers can use to stimulate thought and learning.
32	Teachers should work together as colleagues within and across disciplines and grade levels.	We encourage teachers to form Action Research teams, in which physics teachers meet regularly and discuss instruction.
33	Teachers should focus and support inquiries while interacting with students.	We advocate minimal lecturing and encourage teachers to become more of a learning coach or counselor, asking rather than answering questions.
36	Teachers should orchestrate discourse among students about scientific ideas.	We encourage teachers to use collaborative learning.
36	Teachers should challenge students to accept and share responsibility for their own learning.	We encourage students to reflect on their own ways of thinking and organizing knowledge, so that they increase their self-knowledge and become a more active participant in their own learning.
36	Teachers should recognize and respond to student diversity and encourage all students to participate fully in science learning.	We show students that there are many valid approaches to answering questions and solving problems.
37	Teachers should encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science.	We want students to integrate their everyday experiences with the more formal ideas of physics. We want them to challenge their existing conceptions and build a new, self-consistent, inter-connected web of ideas, operations, skills, and strategies.
38	Teachers should use multiple methods and systematically gather data about student understanding and ability.	In our *Instructional Aids for Teachers*, we provide hundreds of examples of questions teachers may use to monitor student progress. In our *Answers*, we provide common student responses to our questions, as well as many interpretations of possible student responses, so that teachers can better diagnose each student's current state of knowledge.
38	Teachers should analyze assessment data to guide teaching.	We strongly encourage teachers to develop and refine their formative assessment skills.

pg.	NRC Standards say ...	MOP replies ...
42	Teachers should guide students in self-assessment.	Each activity contains a set of "Reflection" questions to help students learn more about themselves and how they approach physics.
	Teachers should use student data, observations of teaching, and interactions with colleagues to ...	
42	... reflect on and improve teaching practice; and	We encourage teachers to model their students' thinking and reasoning, and to discuss their models with other teachers and with educational researchers like us.
43	... report student achievement and opportunities to learn to students, teachers, parents, policy makers, and the general public.	For example, many teachers are terrorized by standardized tests: They are afraid to skip anything that might be on one of them. We encourage teachers to become involved in changing the focus of these tests.
44	Teachers should structure the time available so that students are able to engage in extended investigations.	Each MOP activity is an extended investigation of one facet of physics and how it relates to other facets.
44	Teachers should create a setting for student work that is flexible and supportive of science inquiry.	Our activities are usually open-ended, and we advise teachers to discourage students from looking for the "right" answer. We recommend a shift in focus to the process of doing science, rather than the collection, memorization, and regurgitation of facts.
44	Teachers should ensure a safe working environment.	(not applicable)
44	Teachers should make the available science tools, materials, media, and technological resources accessible to students.	MOP activities are usually done with paper and pencil. When manipulatives are needed, an assortment of common items, such as balls, toy cars, and rubber bands, is usually sufficient. Even resource-limited systems can easily use the MOP curriculum.
45	Teachers should identify and use resources outside the school.	(not applicable)
45	Teachers should engage students in designing the learning environment.	(not applicable)
46	Teachers should display and demand respect for the diverse ideas, skills, and experiences of all students.	And we encourage teachers to help students identify their strengths and weaknesses, and modify their learning styles to optimize long-term goals.

pg.	NRC Standards say ...	MOP replies ...
46	Teachers should enable students to have a significant voice in decisions about the content and context of their work and require students to take responsibility for the learning of all members of the community.	(not applicable) We encourage teachers to use collaborative learning techniques.
50	Teachers should nurture collaboration among students.	MOP activities are designed to be most effective when done collaboratively.
50	Teachers should structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse.	We frequently recommend that teachers discuss the results of each part of each MOP activity to help students become even more aware of how others think and to help students modify their own thinking.
50	Teachers should model and emphasize the skills, attitudes, and values of scientific inquiry.	We believe that optimal instruction occurs when teachers go into classrooms to learn—about student attitudes and thought processes—and then to design interventions to facilitate student understanding.
51	Teachers should plan and develop the school science program.	Each curriculum is unique, because each teacher is unique. There's no such thing as perfect materials. Each teacher brings prior knowledge and a personal style into the classroom. Good materials can be defeated by a bad teacher, and bad materials can be used effectively by a good teacher. So school science is materials plus how they are actually used by teachers. Our *Answers and Instructional Aids for Teachers* help bridge the common mismatch between teachers and materials.
51	Teachers should participate in decisions concerning the allocation of time and other resources to the science program.	(not applicable)
52	Teachers should participate fully in planning and implementing professional growth and development strategies for themselves and their colleagues.	(not applicable)

pg.	NRC Standards say ...	MOP replies ...
59	Teacher enhancement efforts should involve teachers in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding.	Each of our teacher-training workshops are structured this way.
59	Teacher enhancement efforts should address issues, events, problems, or topics significant in science and of interest to participants.	We find that teachers like to have time to talk to other teachers about issues that are important to them, so we always set aside time for participants to do this.
59	Teacher enhancement efforts should introduce teachers to scientific literature, media, and technological resources that expand their science knowledge and their ability to access further knowledge.	Our workshops focus on recent advances in cognitive research and on how to incorporate these advances into their teaching. We also advocate a particular approach to teaching science, rather than focus on our own materials. (In other words, we consider our materials simply to be excellent examples of activities consistent with good teaching.)
59	Teacher enhancement efforts should build on teacher's current science understanding, ability, and attitudes.	We structure our workshops the way we would like teachers to structure their classrooms. Just as each student must be taken into account, we take teachers into account.
59	Teacher enhancement efforts should incorporate ongoing reflection on the process and outcomes of understanding science through inquiry.	(see above)
59	Teacher enhancement efforts should encourage and support teachers in efforts to collaborate.	(see above)
62	Teacher enhancement efforts should connect and integrate all pertinent aspects of science and science education.	(see above)
62	Teacher enhancement efforts should occur in a variety of places where effective science teaching can be illustrated and modeled, permitting teachers to struggle with real situations and expand their knowledge and skills in appropriate contexts.	(see above)

pg.	NRC Standards say ...	MOP replies ...
62	Teacher enhancement efforts should address teacher's needs as learners and build on their current knowledge of science content, teaching, and learning.	(see above)
62	Teacher enhancement efforts should use inquiry, reflection, interpretation of research, modeling, and guided practice to build understanding and skill in science teaching.	(see above)
68	Teacher enhancement efforts should provide regular, frequent opportunities for individual and collegial examination and reflection on classroom and institutional practice.	We have found that single, 3- or 4-hour workshops simply do not work. Our current working model is to start with an intensive one-week workshop, followed by meetings with teachers at least every 9 weeks, and preferably every 6 weeks, to discuss and work on implementation issues. We encourage teachers to meet on their own as well (e.g., in action-research teams).
68	Teacher enhancement efforts should provide opportunities for teachers to receive feedback about their teaching and to understand, analyze, and apply that feedback to improve their practice.	We agree, but we have not made this a central focus of our own teacher-enhancement workshops. As mentioned before, action-research teams can be valuable for providing feedback and improving practice.
68	Teacher enhancement efforts should provide opportunities for teachers to learn and use various tools and techniques for self-reflection and collegial reflection, such as peer coaching, portfolios, and journals.	(not applicable)
68	Teacher enhancement efforts should support the sharing of teacher expertise by preparing and using mentors, teacher advisers, coaches, lead teachers, and resource teachers to provide professional development opportunities.	(not applicable)
68	Teacher enhancement efforts should provide opportunities to know and have access to existing research and experiential knowledge.	(not applicable)

pg.	NRC Standards say ...	MOP replies ...
68	Teacher enhancement efforts should provide opportunities to learn and use the skills of research to generate new knowledge about science and the teaching and learning of science.	(see above)
70	Teacher enhancement efforts should include clear, shared goals based on a vision of science learning, teaching, and teacher development congruent with the *National Science Education Standards*.	(not applicable)
70	Teacher enhancement efforts should include integration and coordination of the program components so that understanding and ability can be built over time, reinforced continuously and practiced in a variety of situations.	We agree. We have developed some novel ways of transforming teachers, such as bringing a pair of teachers to site visits, and discussing the lessons with them afterwards. We encourage school systems to provide resources so that teachers can have time to reflect and to discuss classroom practices.
70	Teacher enhancement efforts should include options that recognize the developmental nature of teacher professional growth and individual and group interests, as well as the needs of teachers who have varying degrees of experience, professional expertise, and proficiency.	(see above)
70	Teacher enhancement efforts should include collaboration among the people involved in programs, including teachers, teacher educators, teacher unions, scientists, administrators, policy makers, members of professional and scientific organizations, parents and business people, with clear respect for the perspectives and expertise of each.	(not applicable)
70	Teacher enhancement efforts should include recognition of the history, culture, and organization of the school environment.	To <u>not</u> do so is counterproductive and doomed to failure.

pg.	NRC Standards say ...	MOP replies ...
70	Teacher enhancement efforts should include continuous program assessment that captures the perspectives of all those involved, uses a variety of strategies, focuses on the process and effects of the program, and feeds directly into program improvement and evaluation.	We have found that our teacher-enhancement efforts are extremely useful for impacting and improving the MOP materials. It is through these efforts that we have recognized the importance and value of detailed Instructional Aids for Teachers.
78	Assessments should be deliberately designed.	Our "Probing for Student Understanding" questions have very particular expected outcomes. Students' answers help teachers diagnose student difficulties, and can be used by teachers to modify instruction.
79	Assessments should have explicitly stated purposes.	(not applicable)
79	The relationship between the decisions and the data should be clear.	(not applicable)
79	Assessment procedures should be internally consistent.	(not applicable)
79	Achievement data collected should focus on the science content that is most important for students to learn.	We advocate a shift of emphasis from static measures, such as memorizing facts and equations, to dynamic ones, such as reasoning skills.
82	Opportunity-to-learn data collected should focus on the most powerful indicators.	(not applicable)
83	Equal attention must be given to the assessment of opportunity to learn and to the assessment of student achievement.	We would go even farther: Formative assessments are woefully under-used, and summative assessments are often overused. There is at times too much attention devoted to achievement. We encourage teachers to give most of their attention to formative assessments. In a sense, MOP activities may be thought of as a continuous formative assessment of student thinking.
83	The feature that is claimed to be measured should be actually measured.	We agree with the sentiment, but we also believe that most assessments are unable to truly measure what is desired.

pg.	NRC Standards say ...	MOP replies ...
83	Assessment tasks should be authentic.	MOP mimics professional science.
84	An individual student's performance should be similar on two or more tasks that claim to measure the same aspect of student achievement.	(not applicable)
84	Students should have adequate opportunity to demonstrate their achievements.	MOP is a continuous formative assessment of students. So, students often develop a good sense of what they don't understand. We suggest that teachers skip some activity questions and ask them later to show students how much they've actually learned.
84	Assessment tasks and methods of presenting them should provide data that are sufficiently stable to lead to the same decisions if used at different times.	This is necessary, but difficult to apply to actual practice.
85	Assessment tasks must be reviewed for the use of stereotypes, for assumptions that reflect the perspectives or experiences of a particular group, for language that might be offensive to a particular group, and for other features that might distract students from the intended task.	MOP assessments are designed to be as free of bias as possible, and we are open to any changes requested by users. However, certain biases are inevitable, such as a bias toward "idealized" situations. We encourage students to become aware of their own assumptions and to learn a variety of context-dependent assumptions (such as when to assume that all surfaces are frictionless).
86	Large-scale assessments must use statistical techniques to identify potential bias among subgroups.	(not applicable)
86	Assessment tasks must be appropriately modified to accommodate the needs of students with physical disabilities, learning disabilities, or limited English proficiency.	(not applicable)
86	Assessment tasks must be set in a variety of contexts, be engaging to students with different interests and experiences, and must not assume that perspective or experience of a particular gender, racial, or ethnic group.	(not applicable)

pg.	NRC Standards say ...	MOP replies ...
86	When making inferences from assessment data about student achievement and opportunity to learn science, explicit reference needs to be made to the assumptions on which the inferences are based.	(not applicable)
175	All students should develop abilities necessary to do scientific inquiry.	MOP activities are carefully designed to promote the individual skills needed to do science, from operational skills such as graphing to reasoning skills and other critical thinking skills.
176	All students should develop understandings about scientific inquiry.	We encourage teachers to model the scientific method in the classroom—to insist that everything makes sense and that everything has a self-consistent explanation.
	All students should understand ...	
178	... the structure of atoms; the structure and properties of matter;	This will be covered in the fourth book in the **Minds•On Physics** series, available Fall 1999. (See below.)
179	... chemical reactions;	(not applicable)
179	... motions ...	The entire first book is devoted to *Motion*, with an emphasis on using and understanding graphs of kinematic quantities vs. time to analyze physical situations.
179	... and forces;	We prefer the idea that objects "interact" with each other. Each interaction produces a pair of forces, one on each object, which can be used to explain and predict the motions of the objects. This is covered in the second book of the series.
180	... conservation of energy ...	We recognize that dynamics is useful but limited, so conservation laws become important, especially for momentum and energy. (This is covered in the third book of the series.) These ideas persist as we explore many other systems and subjects, such as electricity & magnetism, fluids, heat & thermodynamics, light, sound & other wave phenomena, and radioactivity. (This will be covered in Fields, Complex Systems & Other Advanced Topics, the fourth book in the **Minds•On Physics** series, available Fall 1999.)
180	... and increase in disorder; and interactions of energy and matter.	This will be covered in the fourth book in the **Minds•On Physics** series, available Fall 1999. (See above.)