The Evaluation of the Minds•On Physics Project

Executive Summary

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Introduction

Minds•On Physics (MOP) is a high school physics curriculum development project funded by the National Science Foundation (NSF). It builds upon more than ten-years of research in cognitive science by the Physics Education Research Group (PERG) at the University of Massachusetts (UMass) on how people learn physics. It also follows a successful pilot project that tested the feasibility of developing such a curriculum. The current phase of the project was funded for three years beginning in 1993. During the summer of 1994 and the 1994-95 academic year the development team, consisting of the members of PERG and on occasion others, developed MOP activities with the aid of practicing high school physics teachers (alpha teachers). During Spring 1995 additional teachers (beta-2 teachers) were recruited to test the MOP materials during the 1995-96 academic year. A total of 37 teachers eventually had some connection to the project, including a group in New Orleans, LA who acted in a similar role to alpha teachers and a group in Chattanooga, TN who were similar to beta teachers. A week long workshop was provided for these teachers during August 1995. Three one-day follow-up workshops were provided during the 1995-96 academic year.

The evaluation of the Minds•On Physics Project has six components. First, the evaluation team reviewed the written materials: MOP Activities, the Reader, and Answers and Instructional Aids. Second, the evaluation team observed all the workshops to provide the development team with formative and summative information. Third, the evaluation team observed the ways that the alpha and beta teachers implemented the MOP curriculum materials in their classrooms. Fourth, the evaluation team looked for changes in the beta teachers during their year of involvement in the project. Fifth, students were tested for changes in attitudes toward physics and approaches to problem solving. Finally, the evaluation team focused on the ways that the development team and high school teachers interacted with one another.

Summary of findings

First, our review of the curriculum materials (MOP Activities, Reader, and Answers and Instructional Aids) indicates that they are of the highest quality and are consistent both with the goals of the development team and current findings in research in cognitive science.

Second, our evidence suggests that when the MOP approach is used with the MOP materials as a comprehensive curriculum most of the development team's goals are met. In particular, students gain access to knowledge and skills that allow them to develop expert-like, concept-based problem solving abilities that are inaccessible with traditional curricula. In addition, students who used MOP regularly showed a greater awareness of their metacognitive process in solving physics problems than did students who used MOP only occasionally.

Third, there was a wide variety of ways in which teachers implemented the MOP materials. We saw several reasons for this. Some of the teachers, after careful deliberation, made the professional decision not to use the materials. The primary reason for this was the mismatch between the teachers' goals for high school physics and those of the development team. Some of these teachers were also concerned about the frustration that they saw in the students from the use of the materials. This frustration was due in part to the use of MOP as a supplemental rather than comprehensive curriculum. It was also due to the nature of schooling itself, as an activity that promotes task completion rather than learning. Other teachers had difficulty implementing MOP as intended because of their educational situations. Student, parent, and administrators' meager expectations for students in inner-city schools, tied to all the problems associated with low SES, made it difficult for these teachers to do much more than keep the students in their classrooms. There were also some teachers, again in the inner-city schools, that just were not knowledgeable enough about physics or physics teaching to use MOP. And, as we have seen, there were at least two teachers who did not see that MOP was significantly different from what they were already doing.

Fourth, participation in the MOP project had several effects on the teachers. They learned more physics and became more aware of their students' conceptions, ways of thinking, and learning styles. Most of them used collaborative learning techniques for the first time. They were exposed to and learned about constructivism, misconceptions, and other outcomes of research on physics learning. However, while these cognitive

and affective changes occurred in the teachers, they did not seem to have much effect on their teaching.

Fifth, the development of the materials turned out to be so time and labor intensive that the development team had little time to actively encourage and support the implementation of the materials.

Suggestions, recommendations, and implications

The MOP materials are the result of a highly dedicated, skilled, and knowledgeable group of physicists. The result of their efforts is a state-of-the-art curriculum that is far different from anything else available for high school physics. The materials were developed by university physicists with some input and critique by high school teachers. This model is significantly different from what has become the norm in curriculum development efforts. The successful development of the MOP materials leads us to question whether the norm -- the full participation of practicing teachers in curriculum development activities -- is necessarily the best model. However, while that type of participation is not necessary for successful development, findings from our evaluation of the MOP project suggest that authentic and non-hierarchical communication between the development team and teachers aid in both the development and implementation processes.

It was clear from this evaluation that the development team did not have enough resources to keep the development process on schedule, collaborate with the Chattanooga USI, engage in their ClassTalk project, and promote the implementation of the MOP materials by the beta-2 teachers. As a result, the beta-2 implementation was not an adequate test of the efficacy of the materials. This suggests that the difficulties of implementation need to be recognized up front in the project planning process so that adequate time and resources can be devoted to it. We have the following additional recommendations for the improvement of the implementation of MOP materials and approach.

- Teachers need to be supplied with complete sets of curriculum materials well in advance of the start of the school year.
- Training of the teachers to use the MOP materials and approach needs to be "hands-on." That is, teachers should take on the role of student and work through the activities in collaborative groups. In addition, some teachers will need training in physics and in pedagogical techniques, especially in the use of the MOP approach.

- Hierarchies need to be made explicit. While it is clear that the development team has expertise in physics and research on physics learning, the teachers have valuable pedagogical content knowledge that could be used to help development teams design more effective implementation processes.
- There needs to be an "implementation team" in addition to the development team to design and oversee the implementation process. This team should include teachers as full partners, and should actively promote two-way communication among the teachers and with both the implementation team and the development team. It needs to go beyond an "open door" policy and be proactive in reaching out to teachers and guiding them through the implementation process. This could require several years of support. Some of this support could be through the establishment of teacher support groups. However, resources need to be allocated for the support of the groups.

While we have formulated these recommendations specifically for MOP, we feel that they have implications for the implementation of all new curricula.

Finally, a significant factor in the variability in the implementation of MOP was the difference between the development team's and the teachers' goals for high school physics. This difference can be summarized as the development of expert-like processes in contrast with general scientific literacy. This can be thought of as being similar to the difference between learning to be an artist and learning to be an art critic or historian. We feel that both of these goals, the development of expert-like processes and a general scientific literacy, can be accomplished with the MOP materials and approach, if the development team were to state explicitly that scientific literacy is a primary goal of MOP. Clearly this restating of the goals of the curriculum would have little or no effect on its ability to engender expert-like problem solving processes in students. In addition, we suggest that the materials be re-packaged so that mechanics, which now constitutes the bulk of MOP, could be "covered" in no more than half the school year. We feel that if both of these suggestions were to be carried out, teachers would be more willing to follow through with the implementation of the MOP materials, and as a result, the MOP curriculum would help effect a major transformation in the way that physics is taught and learned in American schools.