QuarkNet: Matrix of Effective Practices

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Background

When QuarkNet evolved from a program that set up new centers each year, to one that established ongoing centers connected to the high-energy physics community, factors for what makes an effective center changed. Based on nine years of evaluating QuarkNet and in the last two years conducting eight in-depth case studies, the evaluators developed a matrix of interrelated factors that make a QuarkNet center effective. Data collected over the years that provided information for the development of the matrix included: observation visits of QuarkNet centers and classrooms; talking in person and by phone with participants, mentors, students and QuarkNet staff; written surveys and reports submitted by participants and staff; and through the case studies conducted over the past two years. The matrix is based on the premise that the contemporary focus of professional development is on the organization in which it is provided—the supports, leadership and other factors included in this matrix—as well as on the content and participants (Loucks-Horsley et al. 1998).

Since QuarkNet is not an intervention program *per se* and because each center is unique, the degree to which the factors in the matrix reflect the effectiveness of the center vary. For example, a center may not have to rely on additional grants if the activities and participants are supported by QuarkNet funds. However, a rural center with geographically-dispersed participants often needs extra funds to provide lodging and travel expenses for several day sessions.

In recent years, it was clear that many QuarkNet centers were developing learning communities mostly among the participants, but some of them included outreach to other teachers and to students. It appeared that this development was related to having a more stable participants base and because the center had become well-established. This could not have occurred if QuarkNet had become a typical intervention program with new participants each year. For many rural teachers, QuarkNet centers became the main connection with other physics teachers since they were often the only physics teacher in their school or even their school district.

Two years ago, evaluators were asked to document the extent to which participants became more "professional" because of QuarkNet. Evaluators documented many cases where QuarkNet provided teachers an opportunity to exercise their leadership and professional skills. Teachers lead QuarkNet groups, provide workshops to other teachers and give presentations at professional organizations. Many had been leaders in their schools and school districts, but QuarkNet provided that opportunity for more extensive outreach, which became a source of greater fulfillment for these teachers.

Given this background, evaluators developed the matrix as a means of providing formative feedback to QuarkNet about how to better support the centers—the organization through which QuarkNet serves to meet the program objectives.

Measurement

Each factor, which will be explained in detail below, was rated on the basis of the extent to which the center met a standard for the factor. The standard was determined through what was in the proposal, goals and objectives, and to some extent on the research literature for that factor where applicable (for example, teacher professionalism). Where the standard was met, the center was rated a '2' or "satisfactory." Where the center fell below that standard, the center was rated a '1' for "minimal". In other words, the evaluators determined the factor was there, but there was need for improvement. A '3' was indicated when the center was above the standard or "outstanding" for that factor. There were some zeros indicating that the center shows no sign of including this aspect in their activities or operation.

A note on total score: Above it was noted that these factors are interrelated. If a center has an outstanding teacher or teachers who lead the group, the mentor can rate a '1' and the center is still very effective. The center may not be rated highly for learning communities, but if they meet regularly and have a stable participant population, they are likely to still be effective. The total score shows how effective a center is overall. A total score of less than 15 may indicate a need for more proactive intervention by QuarkNet staff.

Success Factors

Evaluators determined 10 factors that appeared to indicate a center's effectiveness. Again, these factors are interrelated and one or two may be more important for some centers than others. The best way to use the scores is to see the overall picture for the center and determine if the '0' or '1' factors can or should be improved for the center. Also, the matrix may provide a means for determining the extent of support needed from the staff teachers. Strong centers will still need support but perhaps mainly in specific areas indicated by the matrix.

1. Strong teacher leader: The standard ('2') is a teacher who provides leadership in the areas of content and/or technical expert, exemplary pedagogical skills and the ability to model them for other teachers, ability to provide organizational skills. These skills may be resident in one teacher or a team of teacher leaders. If there is a mentor who provides these skills, having a strong teacher leader or leadership is not as important.

2. Strong mentor who understands education and professional development: Some mentors provide the leadership skills mainly of content and/or technical expert and organizational skills. They tend to rely on teachers for pedagogical skills but provide excellent modeling of research methodologies and "habits of mind." If there is a strong teacher leader, the mentor can be rated a '1' because of not having an understanding of education and professional development without loss of center effectiveness.

3. Participants meet regularly: The QuarkNet model is for a one week summer session with follow-up during the year, sessions during the year or a two-week summer session. Centers that are most effective have at least one or two meetings during the year along with the summer session. For some centers there is one meeting during the year at a local professional organization annual meeting, usually local AAPT (American Association of Physics Teachers) where one or more teachers are giving a presentation. Meeting regularly encourages establishing a learning community and increased teacher professionalism as well as group cohesiveness that promotes a stable participant base. Research indicates that follow-up sessions during the year reinforce what is provided during the summer (Loucks-Horsley et al. 1998). The standard for this factor is meeting in the summer and during the school year or meeting at regular intervals during the school year.

4. Meaningful activities - not just talks and trips: While talks by researchers on technical topics or trips/tours of related facilities can be educational for the participants, activities that bring them together as a community and provide useful tools for classroom implementation are seen as more meaningful to them. Gatherings that focus on professional, pedagogical and technical challenges are viewed as helpful and useful. Teacher participants are particularly enthusiastic about the support they receive from QuarkNet mentors and staff, and other researchers. They also appreciate working with other teachers who have overcome similar challenges and can share solutions to problems they all encounter, and thereby enhance their ability to implement content and research activities in the classroom. The standard for meaningful activities then, is focusing on modern physics topics, modeling or discussing how to implement the content in classrooms, conducting research and discussing scientific inquiry methods, and/or developing QuarkNet-related classroom activities.

5. Directly address classroom implementation of activities for all teachers: Centers exhibit a variety of factors that can contribute to successful classroom implementation of QuarkNet concepts and instrumentation: summer institutes that provide veteran teacher presentations on their experiences; researchers who help participants build and troubleshoot instrumentation; meetings during the year that give teachers an opportunity to support each other; researchers or graduate students who go to the schools to help with presentation of materials or troubleshooting equipment. The most successful centers are those where there is support in implementing the concepts, because when it's not available, teachers become overwhelmed by the material or equipment. As above, addressing classroom implementation is crucial. Teachers do not necessarily know how to include QuarkNet-related topics in their courses without specific help with implementation through modeling, discussing with other teachers/researchers and/or being provided resources and materials such as *Particle Adventure* software.

6. Specific support and/or follow up from staff such as helping troubleshoot cosmic ray detectors: Centers that provide regular contact and support are more successful because without it, equipment goes unused and content is not presented. Teachers who are most successful in implementing use of detectors in the classroom are those who have had direct contact with center staff, staff teachers and volunteers in how to set up and use the equipment. Those who present in-depth QuarkNet content are those who have had materials and concepts provided or modeled, so that their time is spent on implementation, rather than creating lesson plans. In recent years, teacher participants have complained that they don't have time to develop curriculum, and they feel it should be developed by QuarkNet staff, or by veteran teachers who have had success with classroom implementation. Teachers appear frustrated that materials that have been developed haven't been disseminated among the centers, and they are left to 'reinvent the wheel.' Even those who have had success with classroom implementation of content and detectors express a need for materials and instructions that would make their job easier in the classroom. Otherwise QuarkNet becomes an opportunity for teachers that they can only tell their students about, rather than immersing them in the science. Another issue that has surfaced is in many cases QuarkNet staff teachers are not in contact with their centers, or available to support them. The centers that would be a '2' in terms of having and giving support to the teachers are those whose staff teachers are available at institutes and in the classroom at least once a year. They also have volunteers who support the teachers, especially in the classroom. Again, where the center has strong leadership, support from staff teachers is not as necessary but regular contact appears to be important for developing budgets and keeping up to date with HEP content and recent developments in QuarkNet.

7. Money for additional activities and/or have additional grants: A common situation among QuarkNet Centers is insufficient funding for all that is required to keep the center going successfully. Without the QuarkNet financial support and many volunteer hours, they could not continue. Many of the centers do not have staff time to seek other funding, but a few have additional grant or departmental funds that allow them to continue and sometimes expand the programs. Often when other grants are involved the focus of the programs change, and the QuarkNet focus is lost to the new grant. One site in particular had funds from other sources for other summer programs and activities involving teachers and students, and for a major event each school year. That Center became known as the acronym for the other funding source, rather than QuarkNet, even though QuarkNet teachers were involved and QuarkNet materials were used. The standard for this factor is seeking additional funding to fulfill the mission/objectives (such as proving transportation and lodging) or provide opportunities that supplement and complement QuarkNet (such as buying equipment or setting up a student outreach project/program).

8. Stable participant base: There are advantages to having new teachers join the program in terms of reaching more students. However, there are many more advantages and successes at centers where there is a stable participant base. Many of the teacher participants who have been involved with QuarkNet for 3 – 5 years cite their ability to "finally understand" the content as a factor in helping them implement what they have learned at the institutes. They say they wish they could start over because at first the material is overwhelming and too complex, but after a few repetitions, they understand it more completely and can convey it to their students more clearly. As indicated in describing other factors, a stable participant base provides an expert group that can help other teachers, be well-versed enough to provide outreach, provide organizational leadership including what are meaningful QuarkNet activities, understand how to implement what they learned in the classroom, and provide resources and materials. In other words, enable a learning community to be created.

9. Address teacher professionalism such as attending meetings of professional organizations: The 2006 and 2007 Annual Evaluation Reports included an extensive sections on teacher professionalism (2006 pp. 6-9 included a literature review; 2007 included data from teacher interviews on how QuarkNet teachers specifically exhibit teacher professionalism, pp. 14-15). In the 2006 report teacher professionals were defined as those who are reflective about their teaching, are committed to lifetime learning, or at least on-going professional development, and are using their skills and knowledge to serve their school and district. This definition was derived from a review of the literature. Through interviews with 24 teachers, QuarkNet teachers were listed as exhibiting teacher professionalism with regard to: serving other teachers in their schools, districts and larger science education community; outreach to students outside of the classroom; holding positions of leadership; lifelong learning and on-going professional development beyond participation at a QuarkNet center. It appeared that QuarkNet is often the catalyst for teachers to engage in professional activities such as being encouraged to make presentations and working together to conduct outreach to other teachers and students. To the extent that the center provides several such opportunities and includes participants that engage in these activities, the center is rated accordingly. The standard is to provide opportunities for at least a few teachers participate. For example, at one center the teachers are encouraged to attend local professional organization annual meetings; about 50% of the teachers attend and most provide science clubs or other activities at their schools. This group meets the standard.

10. Establish a learning community: This aspect of QuarkNet centers was defined in the QuarkNet proposal as "…to create an environment that fosters mutual cooperation, emotional support, and personal growth as they work together to achieve what they cannot accomplish alone…" A cohesive group, as described above for participants meeting regularly, is an important factor for creating an internal learning community that often then moves out to include teachers at several levels, in some cases even the

elementary school level, and students. One of the best examples is a cohesive group in one center that meets regularly, includes teachers providing workshops for elementary school teachers, encourages teachers to attend local AAPT meetings, and involves undergraduate university students as well as high school students. While this is an example of a '3', the standard ('2') would be forming a cohesive groups where teachers learn from one another then also involve students at some level in the activities, even if it is just a field trip to the center, and/or providing outreach to other teachers such as giving presentations or workshops, and/or developing resources and materials to disseminate. A '0' indicates that participants just come together, usually at irregular intervals, to hear a talk, do an activity or go on a field trip without forming a community. The learning community factor, perhaps more than the others, is related to all the other success factors since as in Loucks-Horsley, et al. (1998, p. 37) indicate, "effective professional development experiences build a learning community."

References

Loucks-Horsley, S., Hewson, P.W., Love, N., & Stiles, K.E. (1998) *Designing professional development for teachers of science and mathematics.* Thousand Oaks, CA: Corwin Press.

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(See also references for teacher professionalism in the 2006 Annual Evaluation Report)