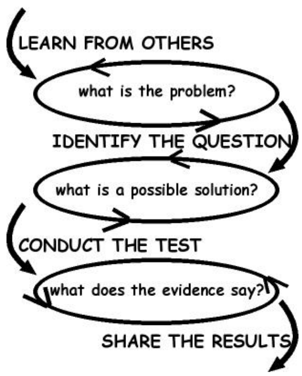
A Quick Guide to Action Research

College Ready Mathematics and Science Partnership

We Learn as We Go

Teachers are professionals and direct their own work [1, 2]. Teachers choose directions that are intelligible; there is a clear vision of the problem to be solved and of the possible solution. Teachers choose directions that are plausible; the solution is perceived as likely to succeed. The adoption by a teacher of a change in their practice usually arises out of dissatisfaction with either the efficiency or efficacy of a current practice. In a flourishing community of practice changes are informed by other members of the community.

A teacher changes their practice if they believe that it is fruitful; that decision needs to be based on evidence. By collecting data that can be used to evaluate the efficiency or the efficacy of the new practice and by sharing this analysis, the entire community learns from the work of each member.



Action Research Spiral

When we invest in changes in how and what we teach our students it is probably because:

- There is a clearly defined problem.
- The solution is likely to work.
- The solution can be tested with data.

The Researcher Is Recast

A teacher benefits from participating in a flourishing professional learning community when they are sharing their ideas and their work. We've been to workshops where a presentation describes a classroom activity but doesn't describe the effect; there is no supporting evidence. And we've been to presentations where student work is shared or changes in student performance are described. There are lots of ideas that sounded good but didn't work in practice. Professional learning communities that share evidence of what worked or *equally important*, didn't work, in practice are more valued by participants. This note summarizes how participation in *College Ready* can help you to measure how well your ideas work by helping you to conduct action research.

The spiral process shown above is familiar; we call it scientific research. So what is different about action research? First, the purpose is pragmatic; we are motivated by the overarching question, what *should* I *do*? The purpose is not to advance pure reason by answering the question; what model of the world is more true? Action research aims to test the value of an action from the point of view of the teacher, rather than to test the correctness of a theory.

This does not mean that action research has less integrity than scientific research; there are standards of evidence whether you are doing action research or scientific research. And it doesn't mean that action research is less valid; the results of action research can be subjected to the same rigorous peer review and publication that can be applied to scientific research. Second, action research is an intervention in the future rather than a prediction of the future. There is no assumption of an objective reality that is unaffected by the observations of the researcher. This does not mean that action research is more prone to bias than is scientific research. In both cases the researcher is responsible for describing any interactions that may have influenced the collection of data and the outcomes of the measurements.

Third, action research is diagnostic. Educational research uses scientific research as a model. However, where complex human interactions are governed by multiple variables that are changing simultaneously, often the best that can be achieved is an interesting correlation. But you are looking for cause and effect, actions that affect learning, and not just correlation. So keep "thinking" in your questions. Because you are a practitioner your questions are probably closer to, "do students think about this idea differently because of this action?" than "do student scores change because of this action?" Although the latter question is more familiar it may only provide a correlation. The former question might provide insight about the actual mechanism.

Finally, the academic world is hierarchical and there is sometimes a bias against participation in research by an "unqualified" teacher. Even teachers can express this bias. Professional learning communities focused on shared experiences of teaching and learning are providing an antidote. An illustration is *Notes from the Field*, a collection of action research reports from teachers in the Maine Mathematics and Science Alliance [3]. A second example was produced by teachers in the Southeastern Eisenhower Regional Consortium for Mathematics and Science Education [4]. Both of these are available from the home page of the College Ready wiki http://uansfmsp.pbworks.com/.

There is a change in emphasis when you are engaged in action research:
- You are motivated by your practice, what *should* I do?
- You and your practices are integral to the design of research, how can I monitor my actions and how can I receive unbiased feedback from students and peers?
- How can you observe and measure the affect of your actions on learning?

A Prisoner of Your Own Design

To share work within a local professional learning community you must invest your most precious resource, time. Unless you are working in a very unusual system the demands on your time of this work will not be valued. But it may take less time than you think because College Ready can provide resources.

And your project will be feasible if you follow some suggestions of from the action research field:

1. Avoid collecting data because it is thought to be free.

There is no such thing as free data. They must be analyzed.

2. Target your data collection on those measurements that are least ambiguous and sufficient to test the action.

Videotapes of student performance are superior to carefully crafted multiple-choice surveys only if you have an unambiguous rubric for the analysis of the tape. Otherwise, *you should expect to spend at least ten hours in reviewing and writing narratives for every hour of real-time video as you search for meaning. And 10:1 is a good rule of thumb for editing of video* to get it to look and sound like something your colleagues will want to watch and provide feedback on. Audiotapes are just as time consuming.

3. Put your measurement techniques on the grid.

You cannot afford to reinvent the wheel, and it may not be as round. By making use of surveys (such as concept inventories) or rubrics (such as the Reformed Teaching Observation Protocol [5]) that have been used by others with published results, you benefit from the achievements of others. And you will not be forced to repeat the mistakes that they made on their path to that publication.

4. Expect to revise your data collection strategy.
Don't wait. Collect some data. If you invest too much energy in defining the perfect data collection strategy you may not have enough energy left to change the method and repeat it when you discover that it is not perfect. The research plan should contain at least one iteration beyond a preliminary data collection followed by an analysis of these data.

5. Anticipate responses and the information that they will provide.
Go through each item that you are going to use to measure the effect of your action and identify likely outcomes. For each likely outcome write down what inferences could be made by asking, "if I see this, what could it mean?" *You may find that some measurements are not likely to provide new information and that some measurements are likely to lead only to unanswered questions.* And as you examine alternative interpretations of the measurement tasks you will be able to estimate the time required to complete them.

6. Target your audience.
In action research you are the principle judge. *Make sure that the measurements can answer your essential question.* You also will want your colleagues to provide feedback. So send your plan to a few critical friends and request their feedback. Since they will not have as much time as you to give to this process, *give these critical friends your anticipated responses* as a "straw document." It will clarify your thinking for them and they can respond more easily to this than to make up their feedback from whole cloth.

7. Enlist help.
Tell your students that you are engaged in an inquiry into your practices as a teacher. Describe the specific question, proposed solution, and data collection strategy. They may be your most valuable critical friends. If possible, design the project so that they share the burden of data collection and analysis with you. The benefit for your students will be in their participation in an authentic research project.

Tell your colleagues. You might discover that they have similar questions and maybe even some answers based on their experiences. And fresh eyes and willing hands in the classroom can greatly improve the quality of the work. For example, the Reformed Teaching Observational Protocol can be a very valuable data collection tool that requires an observer in your classroom. And a hand-held video camera in the hands of a critical friend is much better than a camera mounted on a tripod, both in terms of the variety of perspectives and in the quality of the sound.

Plan the Ascent
The most important part of problem solving is discovering the problem [6]. Finding the question that defines your research is critical and, like all science, begins with careful observation. By observing student behaviors in his physics classes, Jim Minstrell developed one of the first research bases in alternative conceptions in physics education.

> “During my early experience in the teaching of physics, I heard students argue in reasonably coherent ways for their ideas to explain the phenomena of the world. Their ideas were counter to the course content which I had been trying to teach. It was out of a frustration with my seeming ineffectiveness in teaching certain ideas that I began to systematically observe my instruction and its apparent effect on conceptual understanding.” [7]

Do a reconnaissance [8]. Make a map of the terrain with a list of the content in your class by topics. For each area, recall where your students are having trouble understanding or retaining a concept, applying a skill, or making a connection. You may find that problems display patterns that cross over between areas, such as the presence of alternative conceptions that launched a field of investigation in cognitive science.

> “Students exhibit difficulties in distinguishing between heat and temperature; between length, area, and volume; between mass, volume and density; between impulse, work, force, momentum, energy, velocity, and acceleration. Students have genuine difficulties visualizing relative motion from alternative frames of reference. They have great difficulties understanding and using electrical ideas of flow of electricity, electrical potential, and resistance to flow of electricity. The roles of mirrors and lenses in the production of images are confusion.” [7]

Or you may find a new class of problems; like this list of confused concepts, the list of kinds of barriers to learning may be inexhaustible. Recall that our initial surveys of students in the classes of *College Ready* teachers produced a few. Results from the approximately 550 students in *College Ready* classes completing the survey indicate:

- As is well documented for students generally, there is a tendency to approach science as a set of formulas and facts that are to be memorized.
- Students rely on the teacher for expert explanations that they can reproduce.
- Students, and sometimes teachers, believe or act as if they believe that there is only a single way to solve a problem and, if different methods are used then it often thought that different, correct answers can be obtained.
- Students often believe that it is not possible to transfer approaches between dissimilar problems.
- Students believe that they should and do understand why each step in an experimental procedural or problem solving strategy is used. Their teachers do not agree but this difference in beliefs may not be supported by evidence.

Continuously refine your action research questions. As a science teacher you advise students to refine their questions until they are sufficiently well developed to lead to a possible, testable answer. Listen to Minstrell as he restates the logic of the refinement of his question [7]:

> “These results lead me to believe that students sometimes have a conceptual confusion, perhaps a lack of differentiation between related ideas. Since students seem to confuse speed and position regardless of the mode of representation (live demonstration, pictures, or graphs), I conclude that the problem is one of understanding the ideas …”

> “Another significant result from this research is that many of these alternative conceptions exist after instruction ..”

> “Without instruction carefully and properly designed to deal with these pre-conceptions, change in students’ understanding of ideas is left largely to chance. Telling the student

> that his answer is wrong and lecturing on the 'correct response' often has very little effect. Apparently the student's conceptual structure, the internal mental organization of observations and ideas, has not changed."

Look for the toe holds. What are students doing in each of these areas when they are engaged and learning deeply? What strategies work in your classroom? Minstrell grounded his work in his own experience with the question, what strategies are more successful in changing students' pre-conceptions?

> "During the past few years, I believe I have learned some strategies that aid my students in their development of understanding of ideas. When I use these strategies I am more successful at changing my students' conceptual understanding in a lasting way." [7]

Travel Light

Several ways of gathering data that are not resource-intensive are probably better than a single major effort. And if possible triangulate these low-budget methods. Often this means finding evidence from unanticipated sources. Since your research activities are done in addition to your ordinary, overly full schedule, the challenge will be recording this data on the fly. The best method may be the your cell phone or PDA. Otherwise, you can get a separate digital voice recorder for around $50. Save the time-intensive data collection until after making the most of less demanding strategies such as brief notes or on-line surveys.

Often a good multiple-choice question can provide as much information as an extended response. And they are clearly less time-consuming to analyze. Many of your colleagues in the field of physics education research have provided major insights into how students learn with concept inventories. Online surveys that don't just provide statistics over the entire class but provide changes or correlations by individual students, or groups of students, are particularly powerful and College Ready participants can have help in collecting this kind of data.

After preliminary results are available you may wan to use think-aloud protocols. Audio recordings of a single student often contain terrific nuggets that will help you to tell your story. Think-alouds are situations in which you ask the student to simply speak his or her thoughts aloud. After a little practice students can do this, particularly when they are speaking into a recorder and you are not present. Provide a practice session using a familiar context. Provide the subject with a sequence of tasks. In each task define your goal and anticipate possible responses. Difficulties arise when the tasks are so challenging that the subject has difficulty simultaneously thinking and speaking. Reduce, where possible the cognitive load. For example, unless you are interested in the ability to transfer information between steps in a multi-step process use a task that involves only a single step. Subjects also have difficulty verbalizing tasks that are automatic. For example, what could one report about the thinking needed to reproduce a fact? Finally, difficulties arise when the thinking involved is likely to involve a mental visualization. [8]

Scherr has described how the analysis of five minutes of video recordings can be the basis for an hour-long collaborative study of student learning [10]. This suggests a possible approach that fits into the structure of U.S. schools and parallels the more time-consuming lesson study approach used in Japan [11]. For example, College Ready survey data initially identified the question of whether student do or do not understand each step in a laboratory procedure. A video recording of a post-laboratory interview in which the interviewer (which might be someone other than you) simply asks for an explanation of each step can provide an answer to this question and require only a few minutes of tape that will be easy to edit and have good sound quality.

Finally, you will know when the data collection is complete when new data does not surprise you; the data have saturated. Since you have now constructed an apparatus to collect data it may be tempting to continue. As yet unanswered questions might be a more productive inquiry.

In collecting data your model should be Che Guevara and not George Patton:

- Make notes on the fly with an audio recorder or cell phone.
- Use online multiple-choice surveys where possible.
- Use think-alouds where possible to "mine the moments."
- If video recording is desired try to used a fixed scene addressing a targeted task.

A *College Ready* Data Collection Tool

Robert Novak, whose work on concept maps, transfer, and think-aloud protocols helped to establish cognitive science as a discipline had a simple "gold standard": "If you want to know what people think, ask them." Self-reporting (introspection) has often been rejected by psychologists since it does not have the objectivity of the so-called hard sciences. If this was the Renaissance and you had only a single student, asking them would be conversation. Since you have many students and little or no opportunity for conversation, surveys offer an important tool.

If you have a set of questions that could be used to collect data for your action research as a member of *College Ready* you have access to resources, through support from the National Science Foundation that can turn those questions into an online survey. Members of local professional learning communities that are lead by College Ready participants can also make use of this tool. Even teachers who have access to Ed-Line or have learned to use Survey Monkey may find the tool provided by the College Ready network to be valuable. Give it a try!

All that is needed to collect information that can support your action research project:

- In an email to johneggebrecht@gmail.com identify a date upon which you will need a live online survey
- Attach an Excel spreadsheet (or a plain text file with comma delimited names) to that email with the roster of students who will take the survey.
- Attach a document containing the questions that you want to use. Also, provide correct answers.

The questions could be in a conventional format in which you administer a 20-25 item pre- and post-test, such as concept inventories. You might also use a format that is formative and could support whole-class discussion, much as a clicker system does. In a classroom with laptops your students could login to a webpage and respond to multiple-choice questions and their individual responses would be tracked with a time stamp. This method of collecting data is very unobtrusive since it is accomplished within the class. When the survey is completed, the data will be returned to you in the form of an Excel spreadsheet.

You can find an illustration of this "virtual clicker" idea that uses 5-question clusters of questions from commonly used concept inventories:

- Force concept inventory [12]
- Energy concept inventory [13]
- Lawson's assessment of scientific reasoning [14]
- DC circuit concept inventory[15]

You find these examples at http://schoolsciences.net/collegeReady/rs/login.php . You can login as "teacher". Any other clusters of concept inventory questions can be used. Just identify the items that you want in the email described above.

You also have access to a critical friend who in addition to generating online surveys and helping with the analysis of the data will collaborate with you in the construction of curriculum materials that extend the summer workshops into your classroom and into your local professional learning community. Examples of curriculum revisions are available on the College Ready wiki at

http://uansfmsp.pbworks.com/browse/#view=ViewFolder&param=currMaterialsCollaboration .

Simple Statistics

Many reference books are available to guide the use of statistical methods. For our purposes two standard methods are likely to be adequate. These address two frequently occurring questions:

- Are the data collected in a pair of different groups (which may correspond to treatment and control or to different categories) significantly different?
- Are there correlations within the data that indicate patterns or clusters?

The first question can be answered by simply comparing means using a criterion based on a multiple of the standard deviation. A more convincing comparison of two populations can be obtained with a t-test. If two populations are significantly different then the result of the t-test is small. The second question can be answer by using a Pearson correlation.

Different disciplines have different standards that apply to the use of these simple methods. In action research statistics is a "smart eye." When you examine a collection of data you may have the sense that there is a pattern or a shift and a statistical method can confirm or challenge your sense of the data. Listen to the results of the test! Pursuing a belief despite the evidence is a waste of time.

Excel makes quick work of both of these standard tests using the TTEST and CORREL functions. The help pages provided by Excel are adequate to properly set the arguments of these functions. A google search will produce tutorials aimed at students in university classes where the methods are applied using Excel in a step-by-step manner.

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