Barriers to changing Teaching

Barriers to Changing Teaching in Higher Education Science Courses

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RUNNING HEAD: Barriers to Changing Teaching in Science Courses

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Introduction

"How can I become a more effective science instructor?" A question all college science teachers should ask each year. Traditional pedagogical approaches of instructors in undergraduate introductory science courses do not work effectively with many of today's students. Helping students understand ideas is a complex task. Doing it well takes a significant amount of instructor knowledge and skills. Science faculty have little, if any, professional training in teaching. Years of classroom seat time and graduate teaching experience is equivalent to the football expertise of a fan in the bleachers with some experience in pick-up football at the corner field. You would not likely be hired to play in the National Football League. Effective teaching involves the purposeful, research-informed, development of innovative lessons actively involving students in learning. Continuous and intensive teacher and student feedback are part of the process. The priorities of effective teaching differ from traditional beliefs about what college teachers do.

Barriers to Changing Teaching

Change is difficult in higher education because the organization of the institution, its' expectations, and roles inhibit risk taking, ambiguity, and the inquiry required for change to occur (Cohen 1988). How different would it be for a student to sit in a college science course today as compared to similar courses 100 years ago? Other than content covered, what differences in instruction would the student experience? Researchers have suggested causes for a similar lack of change in elementary and secondary education instruction over the past century. They include:

* the culture at large creates strong forces inhibiting change,

* a lack of ongoing staff development, follow up, and monitoring,

* the organizational context and structure of the institution shapes instructors' practice,

* the perceived realities of the classroom influence a teacher to institute ineffective incremental changes rather than the major ones needed and

* instructors' beliefs and expectations about teaching and learning limit change (Cuban 1990).

Higher education literature includes descriptions of barriers to change at the institutional, administrative, and policy level but little is available on barriers to change existing among university faculty at the course and classroom level. A recent study of perceived barriers to change involved science, mathematics, and technology faculty at thirty higher education institutions taking part in a national professional development project (Sunal and Hodges 1997). The results identified barriers similar to those found by Cuban (1990). The most commonly ranked barriers to course level change accounted for 60% of those identified as very important by faculty. They were resources, time, and turf conflicts.

Faculty perceived themselves as having little control over these areas. Barriers ranked much less frequently, in the bottom 40%, were:

* students - weak backgrounds, fear of new kinds of instruction, fear of science;

* personal resistance to change;

* key personnel - unqualified, uninterested, dead wood, little collaboration;

* committees - college, department, and /or curriculum committee approval;

* lack of training;

* leadership issues - difficulty in convincing decision makers;

* changing institution - dwindling resources, credit hours already in the program;

* tenure/promotion issues and

* curriculum materials not available.

Only in these less frequently ranked areas involving students, personal resistance to change, lack of training, and curriculum materials are barriers under the direct control of the faculty member. These areas were noted by a small percentage of faculty, between 1-10%. Overall, change in higher education was perceived as occurring outside the person and beyond immediate control. Although systemic change is a goal in a major institutional reform effort, the place to begin to make immediate and measurable change at the course level is with barriers where personal control is possible and with contextual barriers where neutralization is practical.

Need for Change in Teaching

Higher education faces significant challenges. As scientific research creates new knowledge and as education research identifies more effective methods for teaching science to college students, faculty are under pressure to create increasingly effective science teaching (Magner 1992). Recent research in the areas of inquiry teaching, conceptual development, and preconceptions has led to more innovative strategies for college classroom instruction and to new approaches for creating instructional change in science courses (Sigel 1985 and Driver 1986).

Although faculty are attempting to improve the effectiveness of science courses, the process is slow and the results limited (Fedock, Zambo and Cobern 1996 and Barinaga 1991). Introductory science courses are responsible for driving off many students either from a science major or from taking science courses. Sheila Tobias (1990) reported common features of courses turning off students include: lack of relevance, passive student roles, emphasis on competition and focus on algorithmic problem solving.

In most state curriculum guidelines for school science there is a significant departure from the past, reflecting the national reform movement described in the National Science Education Standards (National Research Council 1995) and in Benchmarks for Science Literacy - Project 2061, (American Association for the Advancement of Science 1993). These guidelines are reflected in higher education criteria for institutional review by the National Association for Colleges of Teacher Education and in criteria for individual teacher accreditation by the National Science Teachers Association. New science

standards contrast with the instructional methods and content focus of traditional higher education science courses (Gilmer, Barrow and Tobin 1993).

Research Results on Professional Development Efforts in Higher Education

Efforts to improve college science teaching have been growing. Workshops, written descriptions of effective practice, the use of expert or peer consultation, and funded course development are types of professional development in use. Faculty, as well as institutions, need to know which of the types are most effective.

Workshops and courses have been the most frequently used type of professional development over the past three decades (Weimer and Lenze 1994). These cover a wide variety of topics, target various faculty populations, and use a range of delivery methods. Long-term effectiveness generally has not been found for workshops of short duration, less than one day with little or no follow up. Multiple day workshops with follow up and monitoring have been reported to result in significant changes in faculty attitude, knowledge, observed classroom instructional behavior, and interaction with students (Herr 1988; Long, Sadker and Sadker 1986).

Most institutions periodically distribute literature to faculty describing specific types of innovative practice ranging from how to develop more effective lectures to how to use technology in making presentations. These materials usually are disconnected from other professional development efforts. List-serves, chat groups, and Internet web sites are other resources. Little research has been performed to determine the effectiveness of written literature distribution and its high-technology modern forms as professional development.

Using experts and peer consultation often involves one-to-one interactions with consultants giving expert advice and/or counseling faculty through professional problems. Or, it may involve peer self-help partnerships. Research indicates faculty are interested and have positive attitudes toward the use of instructional consultation on a personal basis. While there is no clear picture, the research provides some support for specific practices. For instance, Murray (1985) finds some positive results for instructional intervention helping faculty become aware of their own classroom behaviors, analyzing and comparing them with other alternatives and carrying out action research to create change. The analysis of self-recorded teaching tapes and use of student reports during consultation intervention also have been reported to be effective (Weimer and Lenze 1994).

Course development funded by grants from institutions or outside sources typically involves small sums of money given as summer salary or released time. Materials, equipment, or dedicated facilities may accompany money or released time. Some grants provide only materials, equipment or dedicated facilities. The intention is to facilitate faculty development of course curricula and classroom or laboratory instructional activities. Although grant-funded efforts receive positive support from recipients, few studies have examined long term impacts beyond faculty attitude. Existing studies suggest using grants as catalysts for pedagogical and curricular change in a broad based, long term process (Eble and McKeachie 1985; Sunal and Sunal 1991). Successful professional development involves grants in a comprehensive approach including workshops, distributed literature, monitoring with consultative follow up, and peer support groups.

The literature provides some direction, yet more research is needed to identify the effectiveness of various types of professional development in different contexts, of varying duration, and with various target populations. Successful faculty professional development is a complex process involving several integrated components. In addition to the four most frequently used intervention types, there is evidence

that action research facilitates change in an individual's teaching (Cross and Steadman 1996). Through action research, a faculty member investigates currently used practice and problems of teaching. Faculty trained to use an action research approach to instructional development question their beliefs and common sense knowledge about teaching. This process creates informed knowledge immediately useful in the classroom. Action research begins with a concern defined into a problem (Hopkins 1993). It continues with reflection leading to hypotheses and planning of informal investigations. Following collection and analyses of data, conclusions are drawn. The conclusions lead to decision making and revised instructional strategy and/or curriculum. New grounded pedagogical beliefs replacing older, unsupported beliefs are built in a continuous spiral of change and faculty development (see Figure 1). Questions are asked such as: Does the use or frequency of peer-to-peer questions during a lecture result in greater achievement? Does the use of portfolios as a part of an exam effect student interest or attitude? Does coverage of fewer concepts in more depth affect overall achievement? Does the frequency or type of teacher-peer interactions during the class session effect achievement or attitude? Such research is fostered by the use of a partner or team approach. Collaborative partners may be found within a science department or across departments. Sharing of expertise and collaboration enables faculty to approach undergraduate teaching as they approach effective research in their own disciplines - using a team approach. The use of action research by a faculty member responds to the axiom "good research makes a good teacher."

Figure 1 about here

A Framework for Facilitating Change

Research supports a professional development program centered on the belief that interactions as well as intervention play important roles in the process of change. Ongoing interactions during the change process create a personal change in beliefs (Peterman 1993). Change in beliefs does not follow the implementation of change but is produced during its implementation by ongoing interactions between beliefs and practice. Knowledge is constructed within the faculty member during the change process itself.

A professional development program using cognitive apprenticeship centers on intervention and interactions and is an effective means of creating change (Collins, Brown and Newman 1989). This involves a group of learners exchanging roles from teacher to learner and back again. The apprenticeship is designed to change implicit everyday knowledge to explicit informed practical knowledge through shared reflection and action research. The cognitive apprenticeship involves three phases. First is a sharing of beliefs, making them public (elicitation). Second there is an attempt to create cognitive dissonance through discussion, reflection, and observation of alternative approaches for teaching (reflection). Third phase ideas are reconstructed related to defining effective learning and teaching in college science classes (reconstruction). This change process is continuous and iterative. It involves a faculty member in doing, reflecting, learning, and changing. The basic process involved is action research (see Figure 1).

The implications of the research and supporting framework of cognitive apprenticeship for professional development provide guidelines for more effective professional development in higher education. As a response to the need to facilitate change in science teaching in higher education the NOVA program,

NASA Opportunities for Visionary Academics, provides assistance to faculty on a national basis. The program's emphasis is on constructing, connecting and collaborating, using the best of what has been learned through research on faculty professional development. NOVA is supported by the National Aeronautics and Space Administration. Its' goal is to develop and disseminate a cognitive apprenticeship framework for faculty change in order to enhance science, mathematics, and technology literacy of all undergraduate students, with an emphasis on education majors. NOVA was created by a consortium of universities: The University of Alabama, Fayetteville State University, and the University of Idaho.

This professional development effort consists of demonstration of exemplary teaching practices, examples of successful course models, and a staff development and mentoring support system for faculty wishing to implement new or change existing courses. The NOVA framework supports interactive and collaborative learning. Science, mathematics, and technology content is strengthened through integration. Assessment is viewed as more of a learning process than a grading process. The content of the workshop and continuing long term follow-up is reflected in the literature-supported processes used in effective staff development (see Figures 2 and 3).

Figures 2 and 3 about here

The NOVA staff development process involves faculty concerned with teaching science, mathematics, technology, or engineering courses at the introductory level. Participation begins with application and participation in a workshop by a collaborative team of faculty and administrators (elicitation). It continues with a mentoring process during which team members are assisted in developing a proposal for change that will result in innovative teaching (reflection). As the proposal is enacted mentoring continues, along with evaluation of ideas enacted (reconstruction). Part of the mentoring process is site visitation by faculty who have implemented innovative changes in teaching. Further information about the workshops and follow-up activities may be obtained at the NOVA web site, http://www.eng.ua.edu/~nova (see Figure 4).

Figure 4 about here

The results of the NOVA staff development program to date have been measured using quantitative and qualitative research methods on: faculty attitude, knowledge, faculty efficacy, course planning, and classroom action. Faculty from the first 30 institutions, who started the NOVA program two or more years ago, were included in this study. NOVA course models involve innovative strategies and content reflecting the national reform effort now taking place. Sample brief institutional overviews are described in Figure 5.

Figure 5 about here

Assessment surveys were given to participants of the workshops. Among the thirty institutions for which data has been collected, surveys were received from 75 individuals with a 100% return rate. High levels of satisfaction were found in their ratings of various aspects of the workshop. Overall, 91% indicated the workshop had met or gone beyond their expectations and 100% recommended the workshops be repeated. The broad-based approach of the workshops, mentoring, financial support, and collaborative teams was highly rated.

Faculty efficacy relates to personal beliefs about ability to impact students. It was measured using a modified instrument originally developed by Enochs and Riggs (1990). Two types of efficacy were measured: personal efficacy and teacher efficacy. Personal efficacy refers to a faculty member's beliefs about his or her ability to facilitate student potential for learning. A faculty member with low personal efficacy, therefore, believes that no matter what he or she does in a course, some or most students will not learn basic ideas presented. During the NOVA staff development process, faculty with higher personal efficacy were found to be more likely than those with lower personal efficacy to create change and implement innovative modifications to courses they taught. A correlation of 0.46 was found between personal efficacy and degree of change among faculty. Analysis of variance was used to determine relationships between those faculty who have completed innovative planning of course change against those faculty who did not follow through in the change process. Significant differences ($F=4.5$, $p=.04$) were found, supporting the hypothesis that faculty with higher personal efficacy were more likely to create change in college science courses.

Teacher efficacy refers to faculty beliefs about their own teaching ability. A faculty member who has low teacher efficacy believes that, because of their poor teaching ability they cannot successfully teach some or most of the students in their courses. The sample of thirty NOVA institutions found low correlation (0.04) and no significant relationship using analysis of variance between faculty teacher efficacy and completion of innovative course change.

It was concluded that personal efficacy is a more deeply-held value than teacher efficacy. As a less deeply-held value, teacher efficacy is more readily changed in the staff development process. Analysis of questionnaire and interview data supports this hypothesis. Prior to the beginning of the NOVA program, success in creating new courses reported by the participants in this study was greater for faculty with higher scores on the teacher efficacy index. Following the program no significant differences were found with teacher efficacy.

Questionnaire and interview data was obtained from all participants in the study to provide information on additional variables. Analysis of this data supports the conclusion that faculty who described their role of instructor as a facilitator of learning were significantly more likely to plan and implement change. Faculty who described their role as disseminator of the discipline, lecturer, or information provider were less likely to implement significant change in their courses. In addition, knowledge of pedagogy, innovative course design, and the process of course change in higher education was found to be a critical variable. Faculty with greater knowledge of effective teaching strategies and clearer ideas about planning and carrying out change in college courses were significantly more likely to implement change in their courses.

Additional conclusions from NOVA questionnaire and interview data can be summarized as advice to give to faculty interested in creating change. In follow up site visit interviews nine specific conditions are cited as necessary for successful innovative course implementation and institutionalization to take place. The first is that *interaction of faculty between colleges, for example Arts and Sciences and*

Education, relates to successful change. A sample excerpt commonly found in interviews stressed

> "The university is a set of separate worlds. But it's not two worlds. It's just that NOVA and opportunities like it help us to collaborate. I've known my team members from chemistry, physics, and education forever, but as far as really working together, they have their chair and dean and I have mine. Not even chemistry or physics departments interact that much. To have colleges working together on this course is almost unheard of. It defies the bureaucratic organization with purchase orders or anything else . . . There is just no framework for this . . . it was something that needed to be done . . . To me, it's amazing that [we] are not alone in that. All of these different colleges across the country, in the NOVA network, with as many different groups from all different places all saying exactly the same thing. So, there is a tremendous need for those people to collaborate."

Second, *collegial and administrative support is critical in successful change for 90% of the faculty. The greater the change attempted, the greater the need for support.*

Third, *administrator presence in some part of the change process facilitates greater change.*

Fourth, *change begins with the goal to be accomplished, not with the personal or contextual barriers to be overcome.* Faculty at several institutions offering advice to those interested in creating similar change said

> "I would advise them to forget the personality and what my traditional role has been and things like credit hours, turf, and I would think about, is there a common purpose we're trying to reach here? There was for us. Undergraduates are commonly ill prepared in life science. What can we do? What can we do together? Let's just forget anything has happened before."

Others approached change as

> "We were just like Star Trek Voyager and landed on a new planet where there was nobody existing except us and the population to be taught. We just did whatever we were smart enough to do. And then we will figure backwards from that about who owns it, which dean to go to, or whatever about that."

Fifth, *connections with others having a similar goal builds a core of active faculty and administrators.* "We began with the problem of the increasing number of gen ed students and a corresponding decrease in biology majors. We asked others 'can I talk to you about' and 'could you help me with.' And it was successful."

Sixth, *collaborative work starts with building effective interpersonal skills and trust to facilitate change.*

> "Anybody's got to be strong enough in their self-concept, their professional self-concept, to work on this. If you feel threatened at all, you are going to throw up a flag and there were so many times when we started talking, and maybe [XX] would say something about faculty not knowing something and say, 'And no offense, [Jim] . . . So, if I wanted to talk about a stuffy physics professor who's boring everybody to death, they understood that I'm not talking about you, I'm talking about the way things have been.' "

Seventh, *planning for incremental change is a successful staff development process.*

> "It's difficult to totally change the way that you've taught. Even though you want to change radically . . . it's difficult to change radically. So, in one sense, I don't feel like we have entirely changed the way we've taught. What we have tried to do is [to change] laboratory exercises that we did before . . . But, all of that is beginning to change the way that we teach and will continue to change the way that we teach as we go through. I find myself doing things differently every time, a little bit differently than the way I did before because I'm gradually getting into another mode. But, it doesn't change all at once, admittedly. I keep telling the students that the course is a course in progress, it's a work in progress. It's going to continue to develop and merge and take a different track."

Eighth, *action research is an important element for most faculty in creating successful change. This requires a questioning of your common sense, everyday knowledge about teaching and learning.* One of many interview examples includes

> "The way I would describe our course is . . . we have done away with our lecture portion of the course. We have taken the laboratory period and the lecture period and combined them in time and space. So, instead of being three days a week for one hour then one additional period for three hours, then, we just meet for two days a week for three hours. We do everything in an active learning environment . . . I can't imagine going back to teaching the other way . . . The one thing I like about it the most is that the students . . . with their readings . . . is that they are asking the . . . kinds of questions that scientists have been asking for centuries. So they are raising the kinds of questions . . .an evolutionary biologist or researcher answers."

Ninth, *joining a network of faculty within or outside an institution who weekly collaborate and disseminate results of change in teaching is a critical factor in sustaining action leading to success.*

> "We have a learning community that is in its best sense . . . not a rigid hierarchy. We have students teaching us and teaching us in the presence of other students, we can teach other [faculty] in the presence of other students, we have [faculty] teaching us, so our learning community is much more a web than a hierarchy . . ."

A Response to a Science Instructor's Dilemma

"How can I become a more effective science instructor?" The isolated setting in which many faculty find themselves is not facilitative for creating effective course change. Effective course change requires a collaborative, systemic and long term view of faculty development. Plan to begin to make immediate and measurable change at the course level with barriers where personal control is possible and with contextual barriers where neutralization is practical. Develop a joint effort with another local colleague centered on a long term action research process. Incrementally question current beliefs about how students learn, effective pedagogical approaches, and what kind of science literacy is needed by students. Attend staff development workshops with long-term mentoring and feedback. Seek out grant funding providing time, collaboration, and resources for change. An instructor in this study responded to the question, "How can I become a more effective course planner and instructor?" with:

> "I am not teaching science to enable myself to continue research. Instead, I am a researcher and disseminator of knowledge in a discipline. Research must lead both to new knowledge and new ways of effective dissemination. I am teaching science to help <u>all</u> of my students lead a more productive life through scientific literacy."

Summary

Several important outcomes are evident in previous research on faculty professional development and extended through the NOVA experience. Change in faculty will not occur unless there is a dissatisfaction with existing conceptions of science teaching. Creating cognitive conflict with existing faculty conceptions of teaching is an important role of successful professional development. Innovative pedagogical ideas for course change must be made clear and plausible through a variety of collaborative experiences if faculty are to attempt their use. The use of a cognitive apprenticeship involving several types of professional development approaches in a long term program, is effective in creating innovative change in course design and teaching. Effective change is enhanced when administrators value the innovative ideas and skills faculty bring to their courses. Leadership must be more flexible and personal to adjust to individual faculty. Faculty members cannot operate as isolated individuals and be effective teachers in higher education. Change likely will not take place unless faculty work with their colleagues to negotiate and create common understandings related to reform. Leaders alone cannot make change.

While most higher education institutions implement staff development activities, the professional development process is limited and elements are unconnected. Their effectiveness can be improved. It is time to move to more effective teaching in higher education. The foundation of effective faculty development is growth in extending the idea of research into the dissemination and teaching aspect of the discipline through action research in the classroom. But, support is needed for undergraduate teaching in science if it is to be as effective as research indicates is possible. The needs are clear.

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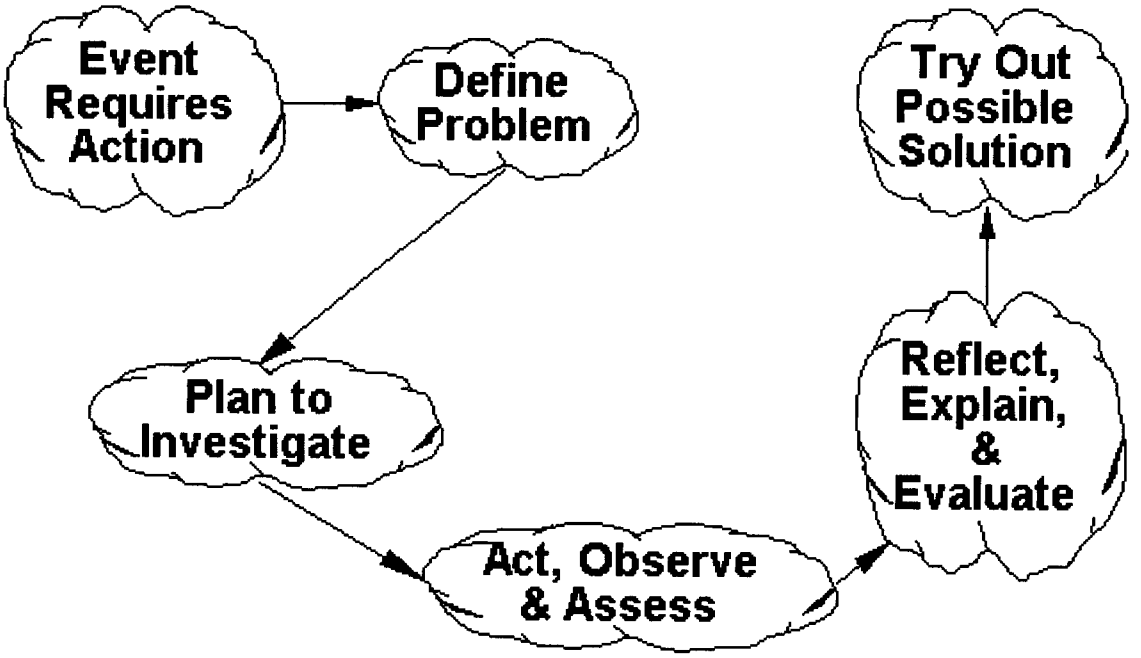

Figure 1: Beginning Cycle of Action Research

NOVA Workshop Content

Sample Innovative Course Models

Innovative Instructional Strategies

New Curriculum Goals and Connections

Strategies That Facilitate Student Learning

Interdisciplinary Approaches to Teaching Undergraduates

Action Research for Higher Education Faculty

Using Technology to Facilitate Learning

Teaching Science to Diverse Undergraduates

Creating Change Using Action Plans

Overcoming Barriers

Funding Innovative Ideas

Figure 2: NOVA workshop content

NOVA Staff Development Process Over Years One and Two

Determining Local Needs in Undergraduate Courses

Formation of an Action Research Team

Science, Math and/or Technology Faculty

Education Faculty

Administrator

Application to Join NOVA

Workshop Participation

Meetings Between Institutional Faculty and Administrators

Proposal Development

Proposal Development Support From NOVA Staff

Proposal Submission

Planning and Development of Successful Proposal

Continued Formative Evaluation of Process

Mentoring and Monitoring by NOVA Staff

Implementation of New or Modified Course

Evaluation of Results on Students, Faculty and Institution

Peer Support and Sharing of Process and Results With Others by Means of the NOVA Network

Participation and Presentation at the Annual NOVA Higher Education Leadership Conference

Opportunities to Apply for Continued Funding for Additional Development Projects and Student and Faculty Fellowships.

Figure 3: NOVA staff development process over years one and two.

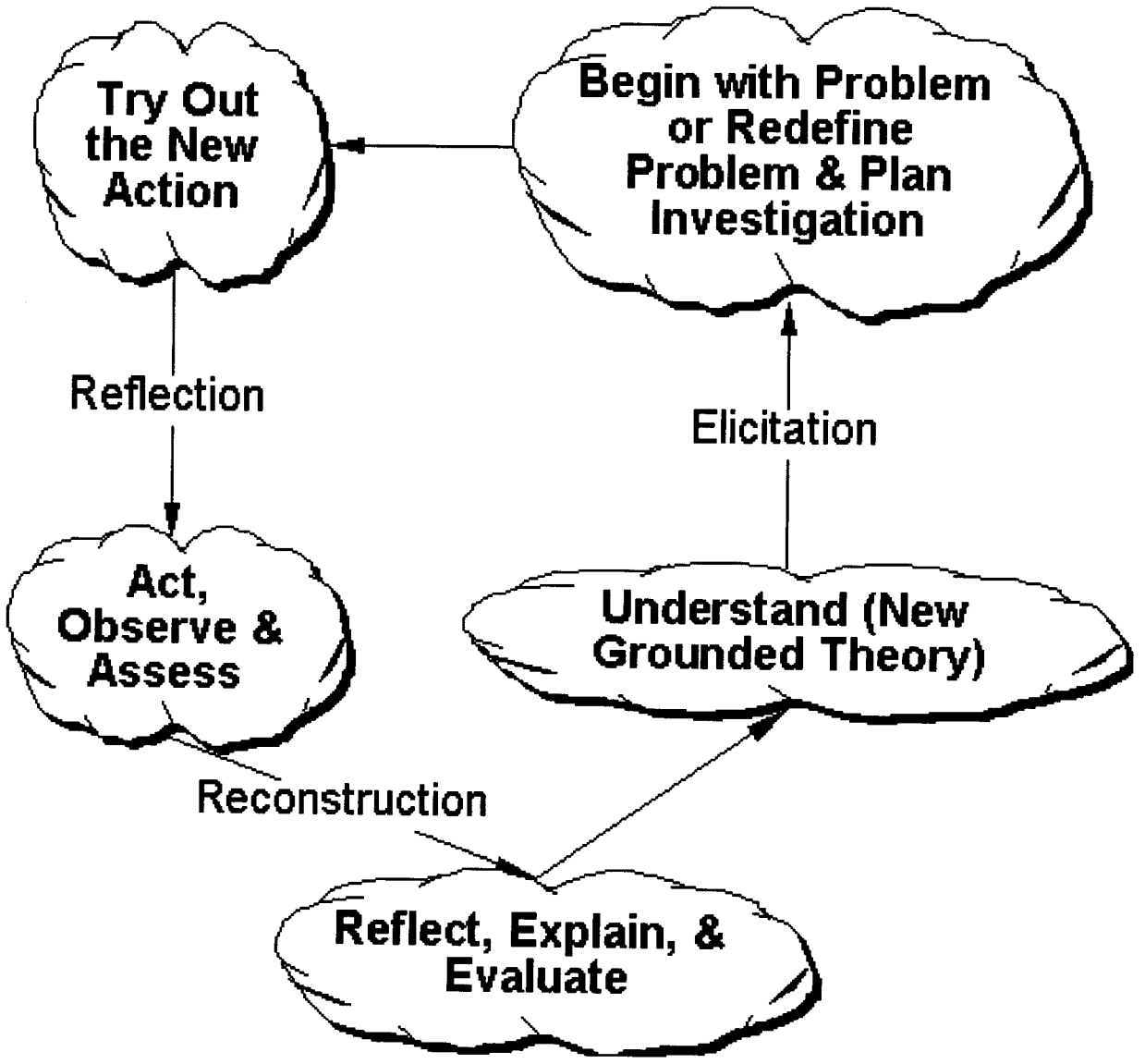

Figure 4: NOVA Action Research Model

Institution	Course Titles	Brief Description & Web Site

Figure 5: NOVA science courses developed including innovative strategies and content.