SCIENCE LITERACY IN THE CRUCIBLE OF SERVICE LEARNING

RIGOR AND RELEVANCE — DEVELOPING CONNECTIONS BETWEEN SCIENCE, EDUCATION, COMMUNITY AND CAREER

Richard Ponzio
University of California, Davis

Marian J. McKenna
University of Montana, Missoula

This article argues that academic service learning at the undergraduate level provides an accessible and powerful crucible for exploring a career in teaching while also providing needed hands-on science literacy experiences for young children. The mixed method methodology used for assessment purposes is consistent with reflection and inquiry, the key elements that serve as the bridge, so to speak between science literacy and service learning. The course described simultaneously develops science literacy, career awareness and social capital of undergraduates and children.

INTRODUCTION

We explore three interactive themes related to academic service learning and learning to teach: Educational experiences that provide an opportunity to learn science by teaching science; learning experiences that develop reflective practice and sense of educational ownership and design; and, how inquiry and reflection serve as an effective bridge between content and context. We begin by distinguishing what makes academic service learning distinct and unique, then describing the current shortage of qualified teachers in the schools, and the state of science education. We define and explain our interactive areas for academic service learning in science. We describe a course designed and taught at the University of California at Davis designed to support undergraduates in becoming comfortable with using inquiry-based science programs and materials to develop an understanding of science and using constructivist teaching methods with children. Sample inquiries and reflective interactions among the undergraduates along with their work in after-school childcare are presented. The case is made that academic service learning that has constructivist and reflective curriculum components and a significant amount of reflection on practice helps fructify the promise of service learning to improve science literacy and civic engagement. A summary that defines the lines of evidence use to assess the work of the undergraduates is presented. Also presented are the lines of evidence that make both undergraduate and child learning visible.

BACKGROUND

Academic Service Learning

All service learning is not equal. In his stirring description of service learning James Kielsmeier(2000) boldly states that "at every level of schooling, youth participation in service is at an all-time high." And then goes on to assert "...the service-learning movement demands nothing less than reconceptualizing the role of young people in modern democratic societies, particularly in the context of schooling" (p. 652). One can argue that this dominant view of citizenship development and community development vis-à-vis service learning is an important aspect of developing social capital within our society. However more can be gleaned from service-learning by including a focus on bringing academic aspects into the forefront. What distinguishes the academic service learning course from a typical service learning course is the role and focus on inquiry and reflection in relation to academic content, thereby making learning authentic and visible.

American Education; The Past Two Decades

During the past two decades public education in America has experienced an increasing emphasis on education standards and its handmaiden, testing, described by Swanson & Stevenson (2002). The No Child Left Behind legislation introduced by the current administration leaves no doubt that school success will be measured by standardized test scores. This emphasis on the use of standardized testing as the most pervasive measure of student learning in the research literature is described by Lagemann (1989). Writing on traditions of educational research on student assessment she states "one cannot understand the history of education in the United States during the twentieth century unless one realizes that Edward L. Thorndike won and John Dewey lost" (p. 185). As we begin the 21st century we find the interest in repeated quantitative analysis continues. The effects of continual testing can, in some ways, be compared to a farmer expecting a pig to gain weight as the result of repeated weighing. Howard Gardner (2002) notes that "although there is consensus among cognitive psychologists "that children must construct knowledge for themselves; they cannot simply be 'given' understanding of any important issue. This insight – shared by thousands of cognitive researchers all over the world – does not prevent legislators from calling time and again for 'direct instruction' and 'drill-and-kill' regimens" (p. 49).

A troubling situation in our schools is that many areas of the country are experiencing teacher shortages and are hiring unqualified teachers on emergency permits. For example, during the 2000-01 school year California had 42,427 teachers in public school classrooms (approx. 14%) that did not have teaching credentials; however during the past two years the number of classroom teachers without credentials is slowly drifting downward. (Shields, et.al. 2003).

Although the National Science Foundation and other agencies have invested hundreds of millions of dollars in curriculum and teaching skills projects, unevenness continues in the amount and quality of science being taught in the elementary grades, according to the latest Trends in International Mathematics and Science Study data (National Center for Education Statistics, 2000). The unevenness has been attributed in part to a generalized avoidance of science as an area of study by undergraduates going on to receive elementary teaching credentials.

The Social Landscape in America; The Past Two Decades

The years 1980 – 2002 have seen broad shifts in the American economy, with swings from the heady heights to gut wrenching lows in the Dow Jones. In the workplace, jobs are created and lost seemingly overnight, meaning that people have to seek new jobs, often in new fields. Retirement savings and investments have waxed and waned. Recent events have brought lawsuits questioning the ethics of America's captains of industry, while spawning hundreds of lawsuits. These same twenty years have seen the birth of the "Information Age" and the rise of the Internet and use of personal computers.

During the same time America has experienced myriad social changes including population diversity and an increased polarity between the 'haves' and the 'have-nots'. There have been significant changes in the definition of "community" as described by Robert Putnam in Bowling Alone (2000). These rapid and hard-to-predict changes have exacerbated the need for education that not only provides teachers and children with knowledge and information, but also with skills and experiences that help them better understand and live in a changing social and economic landscape.

Science Learning and the Development of Social Capital

During the past decade interest in and use of the concept of social capital has increased among educators (Dika & Singh, 2002). The concept of social capital in a theoretical framework was first described by Pierre Bourdieu (1986) in his distinction of the three sources of capital (economic, cultural, and social) and elaborated and expanded by James Coleman (1988). Although the theories of Bourdieu and Coleman differ, each define social capital as the benefits accruing to individuals or families by virtue of their ties with others (Dika & Singh, 2002). Service-learning programs offer a rich and authentic opportunity for teachers and children to develop social capital through project-based activities.

Science Teaching, Science, and Using Social Interactions in Teaching Science

The academic standards tests used in California do not test science mastery until grade four. This lack of accountability, combined with the well documented studies detailing elementary school teachers' lack of preparation and confidence in teaching science, means that for most public school students science is not taught until grade four. The irony in this is that even when science is taught, the overall goal is to impart information and knowledge to the student, so that he/she may be successful on the grade level science test. This educational scenario is contrary to how scientists go about inventing and constructing knowledge, and how scientific investigation proceeds.

Many historians of science have documented how science (as a discipline and body of work) proceeds and develops, but perhaps *The Structure of Scientific Revolution*, Kuhn's (1970), descriptive analysis of science, is the best known popular work. In science, the answers are not in the back of the book, or as Richard Feynman (1969) stated, "Science is the belief in the ignorance of the experts." Scientific inquiry relies on evidence, theories, prediction, hypothesis and continuous inquiry.

The University of California at Davis, the Department of Human Development uses materials developed for use in after school child care sites through a NSF grant in the Youth Experiences in Science (HD-192 YES) academic service learning course. In other words, the NSF-sponsored YES Program materials developed for children to learn science are used by the UC undergraduates as the curriculum for their work with children as part of their UC service learning course. The YES Program materials and the Human Development (HD 192 YES) coursework incorporate learning cycle instructional methods (Karplus; 1977, Lawson, Abraham & Renner; 1989, Marek & Cavallo; 1997) that provides for independent inquiry in the exploration phase of the activity, and for interdependent inquiry in both the concept development and concept application phases. The concept development and concept application phases are critical to academic service learning programs as they provide contextual dialogue and shared work among colleagues. Through the opportunity for the learners to compare their observations, data and theories they learn to use different lines of evidence for they are learning directly from their interactions with worms, snails or other organisms and materials and working directly with their colleagues. Their observations and "meaning making" are critical for their co-construction (and often re-co-construction) of knowledge and understanding.

In the HD1-92 YES service learning course for undergraduates interested in becoming teachers, the underlying assumption is that knowledge is invented. People invent knowledge. It is a human enterprise to invent and construct knowledge, therefore the best way of learning about science and science teaching is to actually conduct inquiries of your own. Some examples of invented scientific knowledge include Pythagoras developing the Pythagorean theorem, Joseph Priestly discovering oxygen, Madame Curie isolating penicillin, Jonas Salk and his colleagues developing a vaccine for polio, and Barbara McClintock winning the Nobel Prize for her work in corn genetics .

What sort of educational program would provide academic rigor, individual and community relevance, and the opportunity to build science and social literacy, skills and knowledge in an authentic and visible way? What sort of teaching experiences help naïve teachers unpack and learn the craft of teaching, review their role as power brokers in the classroom, and learn to reconstruct their view of the teaching ↔ learning enterprise? What are the critical elements and the catalyst to blend the academic and service features to make an effective academic service-learning course for science literacy and effective teaching?

HUMAN DEVELOPMENT 192 THE YOUTH EXPERIENCES IN SCIENCE COURSE

The HD-192 YES service-learning course is offered to undergraduates at the University of California at Davis. The course is housed in the Department of Human and Community Development and is usually taken by undergraduates interested in becoming elementary teachers. The instructional model used in the YES course differs from didactic pedagogical structures as it more closely follows the flow of inquiry and invention found in scientific practice. The course encourages the undergraduates to use constructivist pedagogical structures related to the creation and/or acquisition of knowledge. That is the undergraduates engage the children in inquiring into natural phenomena, and the undergraduate participants are engaged in inquiring into effective teaching practices.

An additional dimension of the pedagogy used in HD-192 YES is helping undergraduate novice teachers explore dimensions of their own power and control in the classroom, arguably an issue for most beginning teachers. Yukl (1989) defines power as "An agent's potential influence over the attitudes and behavior of one or more target persons." The YES course is designed for undergraduates to learn to present science activities that develop science literacy through investigative skills and hands-on activities in after school settings. The course is organized in such a way that teams of three to five undergraduates form teaching teams that go to local after school child care sites and use inquiry-based science programs with children enrolled at the sites. The course includes guided observation of the children, university classroom time where the undergraduates learn to use the materials through peer teaching, and discussions about what constitutes best education practices, and ways to assess learning. The inquiry-based science materials used are those developed as part of the YES Program, an award-winning NSF-funded materials development project specifically targeting children in after school child care. The YES Program curriculum materials and activities catalyze hands-on inquiries of intrinsic interest to children five to eight years of age. Pedagogically, YES units incorporate hands-on, inquiry-based science activities with cooperative learning. They focus on helping young children learn to use the scientific thinking processes of observing, communicating, comparing, and organizing. Each unit includes six sessions. The undergraduate teaching teams are given the leader's manual and the materials to conduct the YES program; they also are provided with training sessions in the use of the manual and materials. The leader's manual used by the undergraduates includes prompts to guide the undergraduate "teaching partners" in planning and implementing the YES activities. The prompts include lesson overviews, background information, a materials list, planning tips, suggested teaching actions, and some specific questions to get the activities started. The lessons incorporate the three-step (exploration → concept development → concept application) learning cycle, whereby the undergraduates assist and encourage young learners with exploration, concept development and concept application to promote understanding.

In addition to the materials used at the childcare site each instructional unit includes supplemental materials and activities in take-home loaner backpacks related to the curriculum that encourage family involvement in real-life home settings. Also, the undergraduates put on Family Science Activity Evenings where the entire family is invited to come and engage in *sciencing*. Several of the YES Program units also include learning centers for use in classrooms.

We did not invent this model, we only adapted it to an academic service learning model that encourages undergraduates to begin along the path of reflective practice described by Donald Schön, (1983), and the writings of John Dewey supporting the position of learning by doing. This view of authentic education has been around for a long time and can be found quite prominently in the Reggio Emilia (Italian) early childhood education system (Reggio Children; 2001), and Howard Gardner (2002). This model exists in many schools throughout the US that have adopted the engaged approach to teaching and learning.

Some discrete instructional structures are used in the HD-192 YES academic service-learning course. The ones identified here are described with the learner as the point of reference. They are presented here in a sequence beginning with a structure in which the students are generally more dependent on the teacher not only for information but also on how well they are doing. Subsequent structures progress toward ones where the student is more interdependent, with the information and knowledge along with evaluation being generated by peer group and teacher interactions. This sequence also goes from least to most constructivist with increased density in terms of social interchange among and between students. The structures scaffold and each can include previous ones (except, of course, the first structure). In practice, undergraduates used one or more of the structures and arranged them according to the goal of their activity/lesson.

The first structure is a dependent interaction (being taught), where the teacher is presenting the knowledge/information and the learner's responsibility is to learn/remember the knowledge for a later use (typically, a test). In this case, the learner is dependent on the teacher for being taught the knowledge/information, and for knowing how well he or she did. How knowledge is made visible in this structure is oftentimes through question answering, and testing. Examples of this model include teacher taught lessons, videos, assigned readings, and listening to presentations.

The second structure is an individual's independent interaction with materials (discovery), wherein the learner is actively engaged in finding something out independently, and without being taught or acted upon. In this case the learner is independently creating, discovering, and/or constructing the knowledge and information. How knowledge is made visible is through share-and-tell presentations, papers, reports and displays. Examples are science fair projects, and independent studies.

A third type of structured learning interaction is where a small group of learners (typically a triad) are working together to solve the same general problem. In this scenario the learners are co-constructing the knowledge by designing and carrying out a project of some sort. This structure includes peer (and sometimes teacher) interpersonal interactions, data gathering, reflection and negotiation. How knowledge is made visible is through verbal and/or written presentations of the findings, results from the project and displays. The outcomes may be structured to have either an individual or group focus. Examples include group projects, laboratory partner interactions and project-based learning.

The fourth type of learning structure (academic service learning) includes a larger group of participants working together and solving a larger problem typically issue-based that has social implications for the community. This structure includes interdependent interactions, data gathering, reflection data presentation and negotiation. It differs from the third type, in that re-co-constructions occur among group members due to the increased interactions necessitated by an extended period of time, a larger group and larger problem. It also differs in that it includes reflection and community-based social implications. Academic service-learning involves public service and public presentations in addition to academic presentations of process and findings. Each of these structures is a useful pedagogical tool, used for different purposes and outcomes. The third and fourth structure interactions build social capital as well as knowledge and skills. This is accomplished through peer interactions and co-investigations into situations and/or issues of interest to the participants. In the YES course for undergraduates both the school age children and their undergraduate mentors are interested and invested in finding answers to their inquiries. Since there are no single right answers they are compelled to find, frame, and resolve their inquiries, thereby making their learning visible to themselves and their co-inquirers.

The Role of Reflection as the Catalyst in the Crucible of Academic Service-Learning

What distinguishes the academic service learning course from a typical service learning course is the role and focus on academic inquiry and reflection. Academic and educational inquiries, designed by each of the course participants are the catalyst to focus their investigations conducted during their "service" into areas of personal and professional interest. The classmates assist each other in gathering data and reflecting on meaning. In the sample course presented here reflection is the key to growth and learning, the means of reliving or recapturing experience in order to make sense of it, to learn from it, and to develop new understandings and appreciation. Reflection comes from the Latin word *reflectere*, which means to bend back. Wade and Yarborough (1966) use a mirror metaphor to describe the process of reflection…

> Imagine a mirror; as a mirror reflects a physical image, so does the reflection as a thought process reveal to us aspects of our experience that might have remained hidden had we not taken the time to consider them," (p. 64). The Latin root of "educate" is *educare* - to draw out. Educators such as John Dewey (1900) have made much of the reflective process as a way of drawing out (expanding) thinking process for both student and teacher. For example in *School and Society* he explains "the statement so frequently made that education means 'drawing out' is excellent, if we mean simply to contrast it with the process of pouring in…The child is already intensely active, and the question of education is the question of taking hold of his activities, of giving them direction. Through direction, through organized use, they tend toward valuable results, instead of scattering or being left to merely impulsive expression" (pp. 53-54).

LaBoskey (1993) suggests to teachers that "individuals need to learn how to process their experiences; they need to bring other knowledge, theoretical principles, and alternative interpretations to bear in any analysis of that experience; in short, they need to be reflective" (p. 10). We argue that the combination of inquiry to gather and aggregate evidence and data, and the use of reflection on the results of inquiry begin the educator on the path of reflective practice.

LINES OF EVIDENCE METHODOLOGY AND MAKING LEARNING VISIBLE.IN THE HD-192 YES COURSE

Data were gathered via analysis of observer surveys, and interviews with children, parents of participating children and undergraduates. Additional sources were photograph-recall interviews of children participating in the YES Program, focus groups, and videotape analysis of children participating in the YES Program (Ponzio, Junge, and Peterson 2001). This mixed method of "pedagogical documentation" is described by Dahlberg, Moss and Pence (1999) as one that involves communication and interaction with the children as well as observation in order to make meaning out of the activity under investigation. Pedagogical documentation is not mere observation that places manifest behavior into predetermined categories of an *a priori* framework; rather the framework is constructed along with the observation content.

The photograph-recall technique is to show pictures to individual children (or pair of children) taken at an earlier YES session (usually one week earlier) where they were engaged in a YES Program activity. The interviewer then asks the child (or pair of children) what they were doing, why, what it meant, and what they learned. This method has the benefits of not interrupting the actual activity, and assessing meaning (learning) that endures a week or so after the activity.

The focus groups were of two types. The first was general, where the undergraduates were asked "what was the nature of the learning in the activities you guided?" The second type of focus group was confirmatory: "Does this explanation (or visual model) match what you experienced in the YES Program?"

All of our data were further analyzed in terms of structural analysis (Peterson & Ponzio, 1999; Piaget, 1970). In this mixed-method process, descriptions of intellectual actions are described in their simplest terms as physical and mental operations which people perform as they learn.

Additional evidence of undergraduates learning core processes of science and becoming more comfortable in teaching science were taken from pre-post questionnaires and semantic differential instruments. Participating undergraduates' view of who does science was assessed with a "draw a scientist" projective measure. The undergraduates each designed an inquiry that included two other undergraduates as research assistants for the study. For example if there are 25 students there are 25 inquiry projects going on. In addition, each participant is helping collect data for two other projects. The projects are designed independently, then reviewed by the instructors as to whether or not they meet the criteria for an undergraduate research study, and also meet the University's protection of human subjects criteria. The inquiry study is one of four major pieces assessed for the undergraduate's final grade. A second measure comes from the supervision observations by the university faculty and also typically of the supervising teacher/child care site director. This aspect focuses on involvement and assessment of teaching craft skills and the ability to organize and implement an effective program. The third measure is the undergraduate's participation in class discussions, quality of reflective papers and self-assessment. The final line of evidence is the portfolio of the individual's progress and learning as a teacher and learner. The portfolio includes multiple lines of evidence assembled by the undergraduate. Typical lines are videotapes, letters from parents and students, reflective writing based on each day of teaching and class meetings, samples of children's work, classroom artifacts, photos of students (where allowed) and results of interviews with students and peers.

How the undergraduate inquires into the assessment of the children's learning is also described in the portfolio. In addition, reflective social interactions with children, parents and peers that extend and elaborate knowledge and scientific literacy, teaching skills and build the social capital of the participants are presented and described.

Evidence of children learning from the HD-192 YES Program Experiences

The YES program taught by the undergraduates did not have the intention of guaranteeing learning in all six dimensions of child science presented in Table 1, for each child. However, the undergraduates were prepared to offer opportunities for development in children of a complex array of activities that defined the complex model. For example, the YES Provides provides opportunities and direct instruction in observation, counting, and generalizing. However, it equally emphasizes the spontaneous transformations of "messing about," (Hawkins, 1970) play, and fantasy (Piaget, 1970) with the materials presented in each lesson. For another example, lessons on worms presented vocabulary and concepts and also encouraged children to talk about raising worms at home with playmates.

In analyzing the impact of the undergraduates on the YES child participants it became apparent that the undergraduates were viewed as an esteemed class of individuals by the children... that is they were late teens and young adults who were lively, engaged, expressive, and exhibited an interest in working and playing with them This in turn made the undergraduates more interested in working with the children.

The YES instructional sessions foster mutual child inquiry by dyadic communications ("look at this!") or by groups of children's sense of what is important including questions such as "how do we get the snails to come out of their shells?" and "can a snail pull a toy car?" The YES Program emphasizes the opportunity for children to direct their own studies or to follow activities suggested by the undergraduate teachers. The program does not strive for children's answers that are correct to generalized standards-based tests, but rather for conclusions that are correct by being observable *vis-à-vis* their own investigations and immediate experience with the materials and their constructed knowledge based on their investigations.

Thus, the effectiveness of the program is defined by evidence of visible behavior on the part of children engaged in the six dimensions of scientific behavior and the continuation of the behaviors over time and in other locations. This is substantiated by parent reports of their children continuing to investigate YES topics (e.g. snail behavior, additional bubble investigations, etc.). Many of the demonstrations of learning in YES show developmentally early versions of what later develops into more mature learning. For example, the observations made by children do not show the exhaustive and systematic identification of all variables expected of older science students, but rather the young children's versions are truncated to briefer, more idiosyncratic proto-processes which satisfy the immediate needs of the child to complete investigations in the YES activity to her own satisfaction.

Demonstrations or evidence of effectiveness in YES Program implementation should be apparent to the undergraduate instructors, the children themselves, adult assistants who staff the child care centers, parents involved with their children after the instructional sessions, and expert observers who watch the instructional sessions in person or on videotapes. Thus, the data of this study involve the reports of each of these groups.

Data for this study of YES implementation by undergraduates were obtained with a series of interviews, focus groups, videotape analysis, instructional session observations (non-intrusive and intrusive), and photograph analysis by children. Content analysis of these data identified six components of child science in the YES Program are presented in Table 1. Each of the components is discussed in the following sections using phrases quoted from the data.

Table 1
Components of Child Science Observed in the YES Program

Perform scientific processes
Transform materials and events
Construct ideas, meaning, learning
Get information, develop concepts
Carry out group theme studies
Relate to other settings and people

Perform Scientific Processes.

Children Showed Early ("Proto") Forms of Scientific Processes. For example, in making observations, the children were seen to observe using multiple senses. Children were also using other problem solving processes and proto-processes and child observation (code) data included "watch," count, measure, compare, manipulate, isolate variables, generalize, predict, "test," "communicate," "explore," "question," and carry out "free form inquiry." The activities enabled children to "ask questions, give own answers, be creative, and be willing to change." Children often were seen to "take from an activity, and then apply it to what they do next," for example they would apply what they learned from making bubbles with a coat hanger to making a new *bubble maker* with a berry basket. These operations were done in the context of materials and events including bubbles, worms, foods and other things that the children reported as interesting and intriguing. The materials and events not only were demonstrated by the children, but they were provided for further interaction and use by the children such as the related take-home backpacks and parent booklet of additional YES activities.

Children were seen to "observe on their own," "talk about what was observed," "relate information," "communicate, and talk through possibilities, plan ahead, and anticipate," "experiment in the form of 'let's see what happens,'" "not always follow what's laid out to do," and create "justifications" (explanations) for what they observed. Comparisons were made as children "tested out different ways to make bubble foam." All of these child behaviors or indicators of mental actions were recognized as the child's ability to use scientific thinking processes.

Interviews with undergraduate instructors and with the adult child care staff, along with videotape analysis, suggest early but important versions of these generally recognized scientific thinking processes. Participants described the activity as "learning while playing" and "not quite measuring and comparing." The use of several of the five senses was called "broad observation." The process activity of the children was described as "science readiness" in its level of application by child care professionals. Also, children were seen to be developing 'basics" and "stepping stones." Participants were certain in their identification of both appropriateness and value of these scientific processes.

Transform Materials and Events

Transformations are physical and mental acts whereby the child changes the given materials and events for her own purposes: curiosity, interest, intention, need, disequilibria, or even boredom (Peterson, 1976). When the transformations are regularized they are recognizable as scientific processes such as observation and comparison. When transformations are used systematically they are recognizable as scientific inquiry. The YES Program activities enabled not only a systematic transformation of events and materials as characteristic of scientific processes, they fostered a more spontaneous transformation characterized as "messing about," "playing with," and "fooling around with." One observation made by the child care site staff was that "they didn't want to talk, they just wanted to play with the bubbles;" another was that "the kids didn't want to sit down and discuss the project, they wanted to **do** the project." It was said by a school site administrator was that this involvement "may not be recognized as 'science,' but it is an early form necessary for learning how to do science." However, spontaneous individual activity also could lead to less cooperative behavior. Undergraduates said that at times "it can be hard for kids to work in groups" and that the children "wanted to be independent." Several noted that "it was easier for the girls to be cooperative than the boys."

Construct Ideas, and Meaning

Children were observed to construct idiosyncratic concepts during YES program activities. Often, particularly at the beginning, the undergraduate instructors tried to organize the learning to make the results uniform. However, they began to recognize that the children were eager to take the materials in directions that were of interest to them as individuals, and to interpret directions in ways that followed their own interests. This observation was recognition that the same activity did not lead to identical ideas, meaning, and learning outcomes in different children. Instead, the children were described as learning different details, facts, and phenomena. They "invented their own conclusions." The result was a "general openness to learning" that was expressed in individual ways, rather than as specific information acquisition.

Get Information, Develop Concepts

Undergraduates identified information acquisition as an important part of YES course involvement. When asked about benefits, they mentioned "learning vocabulary" and "learning processes" as outcomes. One kind of information specially valued was when children were successful at "memorizing." Worm body parts were used as examples of information by several undergraduates and adults. Another indicator of program success was that "kids didn't know, now they know."

Carry out Group Theme Studies
Relate to other Settings and People

Most of the social interaction was to show and tell about the child's own idiosyncratic activity, or to tell others of their interests. There were many instances of multiple monologues in which the purpose of conversation was to participate with one's own reports. A second kind of social interaction was to notice another child's interesting actions and to begin to duplicate it as a start for developing their own individual interests (co-construction and/or duplication). Likewise, parents and children related their own continued science activities at home, play, and school; for example, many reports by parents of continued bubble play were told to interviewers. Overall, the YES academic service learning course provides children participating in after-school programs served by the course with the opportunity to engage in high quality, experiential, science activities presented by young adults interested in teaching. Important benefits of development and learning are provided for both the undergraduate instructors, and the child participants. The effectiveness of the YES program provides a usable package of interesting and engaging materials and activities for involving cross-age teaching, hands-on learning, and parent involvement. Project outcomes include: (1) the spontaneous, non-systematic, transformations of materials and events by the child participants, (2) the construction and application of ideas, meaning, and learning, (3) children are engaged carrying out group or otherwise socially transmitted studies, and (4) children relating the activity and other things they learned to other settings such as home and playground, or with other people including classmates, playmates and parents.

CONCLUSION

Overall, the YES course provides children in childcare sites the opportunity to engage in high quality, experiential, science activities in after school settings. The effectiveness of the YES program provides a usable package of interesting and engaging materials and activities for involving cross-age teaching, hands-on learning, and parent involvement. Course outcomes include: (1) the spontaneous, non-systematic, transformations of materials and events by the child participants, (2) the construction and application of ideas, meaning, and learning, (3) children are engaged carrying out group or otherwise socially transmitted studies, and (4) children relating the activity and other things they learned to other settings such as home and playground, or with other people including classmates, playmates and parents.

The Human Development YES academic service learning course for undergraduates provides evidence that university undergraduate service- learning programs can provide direct and authentic experiences that enroll, engage, and stimulate both undergraduates and the children they teach to learn and apply science. In these programs the educational truism "learn by doing" is employed to serve both the development of science literacy and learning to teach.

Note:
This study was supported in part by Grant #ISE-93-55740 from the National Science Foundation. However the views expressed here are not necessarily those of the NSF, and no endorsements of the findings or conclusions are implied. Additional support was provided by the University of Montana in funding Dr. McKenna's sabbatical work at UC Davis.

REFERENCES

Bourdieu, P. (1986). The forms of capital, In J. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241-258). Westport, CT: Greenwood Press.

Coleman, J. (1988). Social capital in the creation of human capital. *American Journal of Sociology, 94* (Issue Supplement), S95-S120.

Dahlberg, G. Moss, P., & Pence, A. (1999). *Beyond quality in early childhood education and care.* Philadelphia, PA: Routledge-Falmer, Taylor & Francis.

Dewey, J. (1900). *The school and society.* Chicago, The University of Chicago Press.

Dika, S. L. & Singh, K. (2002). Applications of social capital in educational literature: A critical synthesis. *Review of Educational Research,* 72, 31-60.

Feynman, R.P. (1969). What is science? *The Physics Teacher, 7,* 313-320.

Gardner, H. (2002). The quality and qualities of educational research. *Education Week.* (pp. 72 & 49). September 4.

Hawkins, D., (1970). Messing about in science. In *the ESS Reader.* Newton, MA: Education Development Center, pp. 44.

Karplus, R. et al. (1977). *Science teaching and the development of reasoning.* Berkeley, CA: University Press.

Kielsmeier, J. C. (2000). A time to serve, a time to learn. *Phi Delta Kappan, 81*, 652 – 657.

Kuhn, T. (1970). *The Structure of scientific revolutions* (2nd ed.). International Encyclopedia of Unified Science. Vol. 2, No. 2. Chicago, The University of Chicago Press.

LaBoskey, V. K. (1993). Why reflection in teacher education. *Teacher Education Quarterly, 20*, 9 - 12.

Lagemann, E. (1989). The plural worlds of educational research. *History of Education Quarterly*, 29, 185-214.

Lawson, A. E., Abraham, M. R., & Renner, J. W. (1989). *A theory of instruction: Using the learning cycle to teach science concepts and thinking skills.* National Association for Research in Science Teaching. Monograph #1.

Marek, E. A. & Cavallo, A. M. L. (1997). *The learning cycle: Elementary school science and beyond.* Portsmouth, NH: Heinemann Educational Books.

National Center for Education Statistics, U.S. Department of Education. (2000). *Pursuing Excellence: comparisons of International Eighth Grade Mathematics and Science Achievement from a U. S. Perspective, 1995 and 1999.* Washington, DC: U.S. Government Printing Office.

Peterson, K.D. (1976). *An experimental evaluation of a science inquiry training program for high school students.* , Ann Arbor, Doctoral dissertation: University Microfilms #77-4568. Berkeley, CA: University of California, Berkeley.

Peterson, K. D., & Ponzio, R.C. (1999). A structural analysis of adolescent scientific activity and learning. *Journal of Research and Development in Education, 32*, 246-256.

Ponzio, R.C. & Fisher, C.W. (1998). *The joy of sciencing.* San Francisco, CA: Caddo Gap Press.

Ponzio, R. C., Junge, S., & Peterson, K. D. (2001). Science after school. *Classroom Leadership*. Vol. 4 No. 7. pp. 6-7.

Putnam, R.D. (2000). *Bowling alone*. New York, NY: Touchstone.

Reggio Children. (2001). *Making Learning Visible: Children as Individual and Group Learners.* Cambridge MA: Project Zero. Harvard Graduate School of Education.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action.* New York: Basic Books.

Shields, P. M., Esch, C. E., Humphrey, D. C., Wechsler, M. E., Chang-Ross, C. M., Gallagher, H. A., Ghua, R., Tiffany-Morales, J. D., and Woodworth, K. R. (2003). *The status of the teaching profession 2003.* Santa Cruz, CA; The Center for the Future of Teaching and Learning, p.11.

Swanson, C. B. & Stevenson, D. L. (2002) Standards-Based Reform in Practice: Evidence On State Policy and Classroom Instruction from the NAEP State Assessments. *Educational Evaluation and Policy Analysis, 24*, 1-27.

Yukl, G. A. (1989). *Leadership in organizations* (2nd ed.). Englewood Cliffs, NJ; Prentice Hall.

Wade, R. C., & Yarborough, D. B. (1996). Porfolios: A tool for reflective thinking in teacher education. *Teaching and Teacher Education, 12*, 63-79.

Richard Ponzio, Ph,D. is a faculty member in the Department of Human and Community Development at the University of California at Davis and Associate Director of the Center for Biophotonics Science and Technology at UC Davis, responsible for K-12 Education and Outreach. His research interests include cross-age teaching and community-based inquiry models for science literacy development.

Marian J. McKenna, Ph.D. is a professor of Literacy Studies at The University of Montana at Missoula. Her research interests include service learning, cognitive studies, and young adult literature.