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Build a Human Project: Improving Attitude and Increasing Anatomy Content Knowledge and Skills for Middle-Level Students

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Abstract

For four years middle-level students and science teachers have participated in a two-week summer workshop outreach project collaboratively designed and implemented by School of Medicine and Department of Education faculty. The project's goals included improving the attitude of student participants toward the study of science; increasing participants' knowledge of the structure, function, and care of the human organism through inquiry-based hands-on exploration; and developing participants' process skills through hands-on activities. Formative and summative assessment of the program's effectiveness in reaching its goals included quantitative and qualitative strategies. Student attitudes remained high, and even improved significantly during two of the years. Content knowledge was assessed through a K-W-L chart, a multiple choice pre- and posttest, and student feedback forms. Authentic assessment techniques were used to evaluate development of process skills. The triangulated results develop a rich picture of success in meeting project goals.

Introduction

The importance of health science outreach programs to educate and recruit precollege students, particularly members of underrepresented groups, has been recognized for over thirty-five years *(AAMC 1970; AAMC 1978; AAMC 1992)*. Creighton University School of Medicine, a private Jesuit institution in the Midwest, has incorporated outreach programs to expand the pool of well-qualified applicants, matriculants, and graduates from the vicinity. Outreach programs, including the Build a Human Project, are a part of Creighton University's long-term efforts to identify students early and encourage their progress through middle school, high school, college, and professional school. Creighton University's health science divisions, including the School of Medicine, recognize that school educators and medical and health educators share the goals of increasing academic achievement for all students, particularly in the vital areas of science and mathematics that are essential for success in health careers *(AAAS 1989;*

AAAS 1993; NCTM 2001; NRC 1996). Part of Creighton University Education Department's mission is to "promote the general welfare of individuals in the local and global communities" *(CU 2005)*. At Creighton University, teacher educators and medical educators collaborate to achieve these shared goals *(Houtz et al. 2004)*. African Americans are the largest minority population in Omaha, and the Creighton campus is near schools with large minority populations. Research with adolescents in those middle and high schools revealed that, prior to outreach intervention, the students had little awareness of or naive conceptions about medical and health science careers *(Houtz 2005)*.

Middle-level students are at a crucial pivot point in maintaining a positive attitude toward science *(Houtz 1995)*. The National Science Education Content Standard C emphasizes that, as a result of activities through eighth grade, all students "should develop understanding of structure and function in living systems. . . . cells, organs, tissues, organ systems, whole organs, and . . . the organism as a whole" *(NRC 1996, 156)*. To help meet these needs of seventh- and eighth-grade students, Creighton University School of Medicine and Department of Education collaborated to develop the Build a Human Project. The project's goals included:

1. To improve the attitude of student participants toward the study of science;
2. To increase participants' knowledge of the structure, function, and care of the human organism from the molecular level to the level of the whole organism;
3. To develop participants' process skills through participation in hands-on activities, particularly in the construction of models related to human structure ("Build a Human").

Outcomes were specified and outlined prior to the development of the workshop (see table 1).

Each summer 2000–2003, groups of middle-level students and middle-level science teachers participated in a two-week workshop in the School of Medicine facilities. Each morning from 8:00 a.m. until noon, participants were engaged in a wide variety of activities to increase their knowledge and appreciation of the structure, function, and care of the human organism from the microscopic and cellular level through the systems and their coordination. The daily activities, agenda items, presentation procedures, outcomes, and evaluation strategies were systematically organized. Topics

Table 1. Program Outcomes for Students

As a result of participation in "Build a Human," all participants will

Increase the *Knowledge* of
- K1 – structure and function of the human organism
  - K1a – molecule
  - K1b – cell
  - K1c – organs
  - K1d – tissues
  - K1e – systems
- K2 – nutrition
- K3 – the work of scientists and researchers
- K4 – results of lifestyle choices
- K5 – the "human" as more than system functions

Develop (or polish) the *Skills*
- S1 – to work safely
- S2 – to work cooperatively with peers, teachers, scientists, researchers
- S3 – to use the scientific method
- S4 – to use scientific equipment and materials
- S5 – of science process skills:
  - S5a – observation
  - S5b – inference
  - S5c – classification
  - S5d – forming hypotheses
  - S5e – collecting, interpreting data
  - S5f – reporting results
  - S5g – constructing models
  - S5h – measuring
- S6 – of problem solving
- S7 – of critical thinking
- S8 – to make healthy choices
- S9 – to use technology as a resource and tool
- S10 – to communicate effectively with members of the learning community

Improve their *Attitude*/interest/motivation/opportunity
- A1 – toward the study of science
- A2 – toward science teachers – learning together, mentoring
- A3 – toward researchers – observing/working with, seeing progress
- A4 – of respect toward the human organism and the human being

and activities were listed in sequence and linked to guiding documents: the NSES Standards *(NRC 1996)*; National Science Teachers Association *(1992) Scope, Sequence, and Coordination*; American Association for the Advancement of Science *(1993) Benchmarks for Science Literacy*; state standards *(Nebraska State Board of Education 1998)*; and the local public schools science outcomes for each activity (see sample, table 2).

Faculty from the Creighton University School of Medicine shared their expertise with the participants using their individual teaching styles, which included lectures, demonstrations, models, slide presentations, videos, and, most important, hands-on participation. Lectures ranged from ten minutes to one hour, and each day the major focus was on hands-on activities, particularly model development.

Participants increased their knowledge, honed their process skills, and learned to make responsible choices as they

- asked and researched "burning questions" about the human body and health concerns;
- constructed models that represented DNA, proteins, sugar molecules, cells, muscle, bones, lungs, skin, eyes, and ears;
- experimented with digestive enzymes;
- dissected cow eyes and hearts;
- observed real specimens of human brains and spinal cords;
- observed the development of shell-less chicks;
- toured medical research facilities;
- looked through high-powered microscopes;
- made tissue cultures;
- journalled, researched, and collected and analyzed data;
- shared their knowledge, results, and products with their family members and the community.

Methods

Specific evaluation procedures were established to assess the effectiveness of each of the multiple learning goals of this project (see table 2). Thus, an integrative analysis of quantitative and qualitative data in a mixed method study was conducted. For student attitude and achievement, quantitative data was the priority. Those

Table 2. Samples from Chart of Program Outcomes, Guiding Documents, and Evaluation Strategies

Day	Activity	Type	Standard	Outcomes[1]	Evaluation
1	Dynamic demos of biochemistry	Large group	NSES TS[2] B	A1-A5	Observation
1	Assess preexisting science attitudes	Individual	NSES TS C NSES AS[3] A	A1	ATSSA
1	Determine science background knowledge & naive conceptions	Small group	NSES AS E	K1–K5	K-W-L chart; knowledge pretest
1 - 10	Safety discussions	Large & small group, individual	OPS Gr[4] 7,8	S1	Quiz, signed statement, observation of behavior
1-8	Shell-less chick development	Large group, individual	NSES CS[5] C	K1, K1b, S5, S7, S8, S9, S13	Daily journal documentation
1	Simple hands-on experiment	Small group	NSES CS C	K1, S2	Lab sheet, observation
2	Molecule model construction	Individual	NSES CS G NSES CS C	K1a, S5g, S10, A1–A4	Observation, accuracy of model
3	Experiment with living cells	One-on-one	NSES CS C	K1b, S1–S5	Lab sheet
4	Construct cell model	Individual	NSES CS B	K1b, S5g, S2	Accurate construction
5	Cell tissue culture	Small group	NSES CS C	K1b, K1d, K3, S2-S5, A1-A4	Lab sheet, journal

[1]See table 1.
[2]National Science Education Standard Teaching Standard.
[3]National Science Education Standard Assessment Standard.
[4]Omaha Public Schools Grade.
[5]National Science Education Content Standard.

results were simultaneously triangulated with qualitative data. Primarily qualitative data was used to evaluate process skills.

Participants: Participants were recruited from local public and parochial schools whose racially and culturally diverse student

Table 3. Number of Participants per Year by Race and Gender

Participants	2000	2001	2002	2003	TOTAL
Caucasian Boys	3	6	8	6	23
Caucasian Girls	8	4	7	6	25
African American Boys	6	3	1	4	14
African American Girls		6	2	8	16
Hispanic Boys	1			2	3
Hispanic Girls		1			1
Native American Boys					0
Native American Girls		1			1
Asian American Boys					0
Asian American Girls			1		1
TOTAL	**18**	**21**	**19**	**26**	**84**
Teachers	8	7	5	7	27

populations included groups that are typically underrepresented in health professions. Middle-level students with sincere interest and motivation, natural aptitude, and good ability were sought. A committee selected applicants based on an essay, the thoroughness of submitting the other required application materials—an application form and recent report card—and recommendations by two people, including at least one teacher. Groups of up to eight science teachers from culturally diverse urban schools participated each summer alongside the students each morning in the Build a Human activities to broaden and deepen their knowledge of the human organism and of the way scientists and medical professionals work. Each year's enrollment is indicated in table 3. In general, the distribution of participants reflected the diversity of the community from which the population was recruited.

Instrumentation: Formative and summative assessment of the program's effectiveness in reaching its goals in terms of student attitude, content knowledge, and process skills included numerous quantitative and qualitative strategies. Student participant demographic information collected included gender, race, grade, and socioeconomic status (SES). Subjects were divided into two socioeconomic categories: Sufficient (not eligible for free or reduced lunch) and Low SES (eligible for free or reduced lunch). It was primarily a white and African American group. Inadequacy of cell sizes for racial groups is recognized as a limitation in this study. It cannot be presumed that all people of color in the setting share the same attitude.

Attitude Goals Assessment

Germann's *(1988)* quantitative instrument Attitude toward Science in School Assessment (ATSSA; see appendix A) was administered to students as a pretest during the first day of the workshop and as a posttest at the end of the offering each of the four years. This fourteen-item five-point Likert scale assessment instrument was developed to measure the attitude of students in grades seven and eight toward the study of science. For researchers, use of this instrument can help shed light on the relationships that might exist between attitude and student, classroom, school, peer, home, and societal variables and how these variables may be related to science achievement *(Germann 1988)*. Reliability was calculated for combined data sets using Cronbach's coefficient alpha on pretests at 0.92 and on posttests at 0.91. In six previous studies, Cronbach's alpha estimates of reliability were all greater than 0.95 *(Houtz 1995)*.

Results of attitude assessment: Paired samples t tests ($\alpha = .05$) utilizing a 95 percent confidence interval revealed no significant difference in attitude toward science from the pretest to the posttest in 2000 and 2003. Significant improvements in attitude toward science from pre- to posttest were revealed in 2001 ($t = 2.706$, $p < .05$) and in 2002 ($t = 2.051$, $p < .001$).

Content Knowledge Assessment

K-W-L chart: One strategy for assessing growth in content knowledge involved developing a K-W-L chart during an initial session and expanding the chart as the workshop progressed. Each year's initial K-W-L chart revealed that participants came into the program with some limited background knowledge (K) of the systems and organs of the human body and an awareness of highly publicized health issues such as the harmful effects of smoking. Students indicated that they wanted (W) to learn more about the internal functions of the human organism and to learn answers to specific health concerns affecting them or family members.

During the first year, as the workshop progressed, medical students assisted in expanding the "what we learned" (L) segment of the K-W-L chart by extensive notes on chalkboards around the perimeter of the laboratory/classroom. Students copied the information into their journals. This procedure was eliminated in subsequent years because students were distracted from the activities at hand while writing notes. Instead, at the end of each morning, students listed and turned in "Ten New Things I Learned Today." This kept emphasis on learning for the students and served as formative feedback to presenters on participant interest and comprehension. Forms were collected, copied, acknowledged, then returned to the participants the next day for their journals. Over the remaining three-year period, 457 lists were gathered.

Findings of K-W-L: The first year, program implementers observed that student participants simply copied notes from the board into their journals. This offered no valid assessment of students' comprehension, application, synthesis, or reflection. After the first year, the practice of writing details on the board was minimized. Instead, at the end of each session, students made a list of ten new things they had learned.

It is noteworthy to mention that even though spelling might sometimes be incorrect, students' information recall remained accurate or factual. Student lists were more extensive and detailed after presentations that included a multimodal format. The nature of responses could be categorized into six types:

1. **Recall of facts.** "Muscle fibrils contain two kinds of filaments, action and myosin." "RNA carries the genetic information from DNA." The vast majority of responses (76%) fit this type.
2. **Skills.** "I learned how to build base models GC & AT, and sugar and phosphate models." "How to candle an egg." "How to grow a chick without a shell." "Testing reflexes with the hammer thing." (11% of responses)
3. **Impacted by sensationalism.** "The lungs of a smoker are disgusting!" "If you shatter your cheekbone your eyeball could drop into the sinus." "One way to relieve pressure on the brain was drilling a hole in the skull." (6% of responses)
4. **Correction of naive conceptions.** "The heart does not sit in the body up and down but rather at an angle." "The brain doesn't get oxygen directly from the sinuses like I thought." "Your fingernails don't really continue to grow after you die. The skin shrinks back." (3%)
5. **Mentioning mnemonic connections.** "The cochlea looks like a snail." "I learned a chant to remember the bones." (2%)

Table 4. Knowledge Test Results

Year	Knowledge Pretest Mean	Knowledge Posttest Mean
2000	NA	80.8%
2001	38.5%	73.1%
2002	53.1%	86.5%
2003	52.9%	71.4%

6. **Personal meaningfulness.** "Now I know why my aunt with emphysema has to use an oxygen tank." "My brother was in a car accident, but the skull has not evolved enough to protect the brain from cars, guns, or drugs." (2%)

Analysis of students' open-ended learning responses seems to indicate that the students presumed that program directors expected factual statement responses, even though this was never expressed, emphasized, or rewarded. This may be associated with the teaching style of the instructors. This warrants further correlative study.

Knowledge Pre/Post Test

A written exam served as a quantitative measure for assessing achievement in content knowledge. During the first year of the program, assessment items based on information presented were developed by teacher participants and polished by the education/research director. Twenty-six knowledge, comprehension, and application multiple choice items were selected and administered as a posttest on the last day of the workshop the first year. In subsequent years presentation content remained fundamentally the same, and twenty-five multiple choice items were selected and administered as a pre- and posttest. Table 4 shows mean scores for each of the four years.

Results of paired samples t tests revealed statistically significant differences between the means for the pre- and post-treatment effect each of three years (2001 [$t = 9.773$, $p < .001$], 2002 [$t = 9.156$, $p < .01$], 2003 [$t = 2.05$, $p < .05$]). Reliability was calculated using KR-20 at 0.82.

ANOVAs were run to see if there were any between-group differences for race for both the pre and post variables. Significant differences were found between racial groups on the pretest variable. However, given the weakness of the racial distribution, it is inappropriate to make cross-race generalizations. There were no significant differences between males and females or between Caucasian students and students of color on the posttest variable.

Bone Identification Mastery Quizzes

Students were taught the names of bones utilizing multimodal pedagogical strategies such as repetitive chants, songs with movement, flash cards, labeling worksheets, peer drills, and games. When students were confident that they could correctly identify the bones, they were quizzed by an adult instructor, medical school student, or teacher on a complete skeleton. If they succeeded without any errors, students received a certificate. All students earned the certificate by the end of the workshop each year.

Process Skills

Authentic assessment techniques were used to evaluate development of process skills. Each day students actively participated in hands-on activities, laboratories, and model development. For example, for the objective "Given a model of the molecule, the participants will accurately construct a sugar molecule," accuracy was assessed by observation by the workshop facilitators and teacher participants. Formative feedback was continuously given to the student participants until the skill was mastered.

Summative evaluation of students' application of content knowledge and process skills was achieved during final presentation at the culminating open house. Workshop facilitators observed as student participants explained their "human" constructions to their fellow participants, peers, family, and community.

Discussion and Conclusions

The Creighton University School of Medicine and Department of Education presented a unique and effective summer learning opportunity for middle-level students. Appropriate, valid, and reliable strategies for measuring student attitude toward science *(Germann 1988)* and changes in student content knowledge have existed for decades *(Dancy and Beichner 2002)*. To evaluate the attitude, content knowledge, and process skill goals for this endeavor, few readily available or traditional measurement instruments were appropriate. Therefore, assessment strategies as unique as the workshop were incorporated. Results of paired samples *t* tests for attitude and knowledge indicate positive outcomes. However, these results cannot be generalized to a much broader student population. Students recruited to the program were required to have a grade of at least C in their science classes, two letters of recommendation, and a letter expressing their interest in participating in this science program. This limited population responded well to accountability and emphasis on learning. Even though scores on the attitude pretest were high, posttest mean scores were higher every year, and the increase was significant in 2001 and 2002. This student population was highly motivated to earn certificates in what was almost a competitive race; in addition, multimodal opportunities for review and practice enabled the students to absorb what they had learned in faculty presentations and lab activities. However, there is still a need for a methodology to evaluate inquiry-based pedagogical strategies that incorporate development of science process skills.

Accessing Materials

Information on the Build a Human Project and teaching units is available at http://puffin.creighton.edu/BuildAHuman/. For more details, please contact the authors.

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