Mentoring BUGS: An Integrated Science and Technology Curriculum

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The current study describes an authentic learning experience designed to develop technology and science process skills through a carefully scaffolded curriculum using mealworms as a content focus. An individual mentor assigned to each 4th and 5th grade girl participating in the program delivered the curriculum. Results indicate mastery of science process skills related to research questioning, forming hypotheses, developing procedures, and writing a conclusion, while analysis was an area warranting improvement. Presentations by participants suggest strong knowledge of PowerPoint and Excel and the ability to use this knowledge to report scientific findings.

Dyani becomes very excited when she talks about her experiences with BUGS. Now these are not just any BUGS. In fact, we are not talking about arthropods at all, but rather 4th and 5th grade girls who are participating in a program at the University of North Texas (UNT) called Bringing Up Girls in Science (BUGS).

BUGS is a gender equity grant funded by the National Science Foundation (NSF) and provides an after school environmental science program for 4th and 5th grade girls. The goal of the BUGS program is to provide ex-
ceptional learning experiences that increase girls’ knowledge, interest, participation, and self-concept in areas related to environmental science as they engage in hands on science and technology learning experiences. These goals are facilitated by numerous partnerships which include: local elementary schools, parents, mentors, the Texas Center for Educational Technology (TCET) and the Elm Fork Education Center, a public education branch of the UNT Environmental Science Department.

At the beginning of each year, BUGS recruitment packets are distributed to principals, teachers, students and parents in partner schools around Texas and New Mexico. Simultaneously, informational presentations are conducted to provide information about the program including criteria for participation and application materials. In an effort to provide equal access for all program participants, bus transportation is provided throughout the year. Girls are picked up from each of the partner schools and transported to UNT one day each week. At the conclusion of each BUGS after school meeting, each girl is returned to her place of residence.

From the applicants, approximately forty 4th and 5th grade girls are selected to participate in a yearlong science program. The girls participate in a variety of carefully selected hands-on learning activities inside and outside the classroom. Participants interact with mentors, and parents receive training to help facilitate program goals. The BUGS program has demonstrated that such a program can enable significant cognitive, social, and emotional growth for girls participating in the program. More information about the BUGS program may be found at the following website: http://www.coe.unt.edu/bugs/index.html.

**DISCUSSION**

**Who are the TAMS Mentors?**

Mentors for the BUGS program are drawn from a pool of female high school students from the Texas Academy of Math and Science (TAMS), a program for gifted and talented high school juniors and seniors who complete two years of college coursework at UNT while finishing requirements for a state high school diploma. The TAMS mentors are the frontline mentoring source for the BUGS girls. Responsibilities of the TAMS mentors include assisting the mentee with a science project involving the use of technology, and making biweekly contact with the mentee over the course of the academic year (Adams, 1999). Conceptually, the TAMS mentor is a guide.
She is there to assist the mentee with regard to acquisition of technology skills, science knowledge, and science process skills. Also, the TAMS mentor creates a social context that fosters interest, participation, and self-concept related to science by encouraging the mentee to think reflectively, question effectively, and develop personal responsibility for her own learning (Ellis et al., 1999; Adams, 1999; Siegel, J. & Shaughnessy, M.F., 1991).

The TAMS mentors are high-achieving females who have actively pursued placement in a science and math academy for gifted and talented youth. Each provides a worthy role model for encouraging interest and participation of elementary school girls in science. Please note, it has not escaped our attention that TAMS is a unique program and would not meet the criteria needed to replicate. For this reason, we suggest there are many alternate school organizations such as the Science National Honor Society and the National Honor Society that would serve as a potential pool of mentors for institutions interested in developing a program similar to BUGS. Regardless of the mentor source, it is critical for the mentors to be well trained and monitored to insure success for the program participants. In the next section, the training program and mentor quality control aspects related to the Mealworms Yum! Yum! learning experience will be described.

Selecting, Training, and Monitoring the TAMS Mentors

The selection process for the TAMS mentors starts with an online application. A selection committee then screens applicants. Potential mentors are rated with regard to science content knowledge, science process skills, technology skills, and the ability to communicate effectively in both oral and written communication. Applicants receiving the highest ratings are selected.

After the selection process is complete, a series of induction activities for the mentors is initiated. First, mentors receive a two-hour orientation training to familiarize them with the BUGS program. A second type of training for the TAMS mentors involves participation in a two-hour workshop to familiarize the mentors with the cognitive, social, and emotional development of the students with whom they will work, as well as the role of the mentor to facilitate development in these same areas. Monthly evaluations occur during the after-school meetings and are used to monitor the effectiveness of the training throughout the academic year. TAMS mentors receive individual feedback from the evaluator regarding their performance and are retrained as needed. Finally, all mentors receive hands on training related to implementation of the science curriculum.
Two options for mentor training for the science curriculum are available. A traditional three-hour training workshop is used to introduce the mentors to the Mealworms Yum! Yum! curriculum. The desired metaphor for a TAMS mentor interacting with a BUGS girl is a mentor is a guide on the side. It is the BUGS participant who initiates questions. The TAMS mentor responds to the mentee with probing questions that advance inquiry and focus the learning experience. The yearlong mentoring relationship is one-on-one (e.g., each mentor is assigned only one mentee). Using a carefully scaffolded curriculum, the TAMS mentor functions as a more knowledgeable person actively seeking to maximize learning in the zone of proximal development for each of the 4th and 5th grade girls. The TAMS mentor may engage in any or all of the following roles and responsibilities: role model, coach, motivator, advocate, sponsor, advisor, supporter, gate-opener, encourager, and talent developer.

For mentors unable to attend the initial training, a second training option is available on CD. There are ten separate video clips introducing the mentor to the Mealworms Yum! Yum! curriculum. Topics include the mealworm curriculum, the sequence of activities, setting up and maintaining a mealworm colony, journaling, observing, inferring, variables, hypotheses, data tables, graphing, and analysis/conclusions. The training videos total 57:10 minutes and each of the video segments for the mealworm curriculum ranges from 1:03 minutes to 12:41 minutes in length. The materials used in the videos accompany the CD so that TAMS mentors unable to attend the traditional training can participate in the learning experiences before attempting to introduce the curriculum to the mentee. We have also extended the BUGS program to three distance sites (Wichita Falls, TX, Bernalillo, NM, and Decatur, TX). The CD training option can be used to introduce the mealworm curriculum to the participants at the distance sites. Each mentor receives approximately three hours of training prior to working with a BUGS participant. Mealworm training videos can be viewed at the following URL: http://www.coe.unt.edu/bugs/mentors.trainingvideos.html.

Finally, quality control of the mentoring aspect for Mealworms Yum! Yum! is accomplished via an onsite science consultant, participant surveys, and review of videotapes showing the interactions between the mentors and mentees. Approximately two hours of the learning experiences are videotaped and reviewed bimonthly in order to monitor and improve the curriculum and mentoring relationships.
Mealworm Yum! Yum Curriculum

Mealworms: Yum! Yum! provides elementary students with a fresh approach for learning science process skills. The curriculum is not just a collection of fun activities; it is a carefully planned, step-by-step approach using a Do – Talk – Do or learning cycle philosophy that is constructivist in orientation (Piaget, 1952; Vygotsky, L.S. 1978; Vygotsky, L.S. 1986; Ausubel, 1963; Marek, E.A. & Cavallo, A.M.L. 1997). All participants complete these learning experiences that prepare them to engage in self-selected authentic experiments for a final project presentation. The proscribed curriculum includes an initial activity that is used to engage the students and focus their learning toward a specific science process skill. The activity is followed by an introduction of the content associated with the targeted science process skill and is then elaborated by a “hands-on” investigation to reinforce the application of the science process skill and concepts that are being developed. As the students move through the activities and investigations, they sequentially build on previous knowledge and process skills they have experienced in previous lessons. They learn by doing. The goal of the curriculum is to equip students with the necessary skills and knowledge needed to design and conduct their own original investigations. Specific elements of the scientific method include: observation, inferencing, forming hypotheses, setting up and conducting an experiment, collecting qualitative/quantitative data, analyzing data, and forming conclusions. An overview of the scientific method is presented first, and the participants are provided with reporting guidelines to create a final presentation. The curriculum is delivered by the TAMS mentor over six two-hour periods totaling twelve hours for the learning experience. A minimum of two after school sessions (four hours) are reserved for working on the final presentation.

For example, the first series of activities focuses on one of the most fundamental process skills, observation. An attempt is made to thoroughly define and practice the skill of observing so it will not be confused with making inferences. An outline of the observation activities is described below.

Do – Engage and Explore. The students begin by observing three classes of animals: a caterpillar (Insecta), snake (Reptilia), and an earthworm (Oligochaeta). Using a compare-and-contrast approach to observe three animals, which are “wormlike” but clearly representatives of three different classes of animals, is an interesting activity for elementary students as they begin to develop their observation skills.

Talk – Explain. Following the introduction of the “Do” activity, the students are introduced to two types of observations, qualitative and quan-
titative. Each weekly learning experience uses small 2-4 person groups, and large group debriefing discussions involving all participants at the conclusion of each learning experience to facilitate the learning process. The small group debriefing activities are student-driven, while the teacher guides the large group debriefing activities. The debriefing activities allow students to verbalize their understanding of the advantages and disadvantages of the two types of observations. The students should understand that qualitative observations describe particular phenomena, while quantitative observations count, measure, time, or find quantities of things. Quantitative observations tend to be more factual in nature and not as subject to inaccurate interpretation as qualitative observations.

Do – Elaborate and Evaluate. The elaboration activity directs the student to use the five senses (see, smell, taste, hear, taste) to describe a mealworm. A set of guiding questions is used to focus the student on gaining conceptual understandings regarding qualitative and quantitative observations. The student also makes drawings of the mealworm. All information is recorded in a journal because recording observations is an important characteristic of all scientific investigation.

Other elaboration activities involve making observations of a pupa and a darkling beetle. Individual observations of each life cycle stage are followed by a comparison of the two life cycle stages (larvae and adult). Students are encouraged to continue self-selected learning experiences at home using various forms of electronic communication to facilitate interactions with their mentor.

Science Process Skill Survey Results

Figure 1 shows the results of the Science Process Skill Survey given to each mentor/mentee pair completing the program. Following the conclusion of the mealworm unit, mentors and mentees were asked to respond to a Likert scale survey. Respondents were asked to rate each survey question using a 4-point rating scale (1 = strongly disagree; 2 = disagree; 3 = agree; and 4 = strongly agree). The process skill survey questions are shown in Table 1 and include statements about forming hypotheses, conducting research on the Internet, formulating a procedure, setting up and completing an experiment, analyzing data and drawing conclusions based on observations and conclusions. Results of the survey show that both mentor and mentee perceptions regarding use of the scientific method were above 3 on a 4-point Likert scale. The exception was in the area of Internet research which was
2.47 and 2.56 for the mentors and mentees respectively. In general, both mentors and mentees either agreed or strongly agreed with the survey statements. Mean survey responses for mentors ranged from 2.82 to 3.68 and mean responses for mentees ranged from 2.65 to 3.65. Anecdotal and video taped information by the researchers on this project noted that both mentors and mentees tended to move through the Internet research rapidly without recording information found during the search. This lack of an introduction was also noted in the PowerPoint presentations given by the 4th and 5th grade girls at the conclusion of the mealworm unit. This would explain ratings that indicate disagreement with the survey statement, “We conducted Internet research to write the introduction to the mealworm project.

![Chart](image)

**Figure 1.** Mean Response for B.U.G.S. and T.A.M.S. Science Process Skill Survey

**Creating a PowerPoint® Presentation**

Students were initially introduced to PowerPoint® and Excel® graphing by an educational technology expert during two separate learning experiences, a total of four hours of instruction. The instruction took place in a school computer lab and each student had access to a computer. The instructor introduced topics that included creating a basic presentation, using a design template, changing font color/size, inserting clip art/pictures from files,
and creating slide transitions. Additionally, the girls learned to create bar and line graphs using Excel®. After engaging in the learning experiences, each mentee was able to demonstrate mastery of all technology skills associated with PowerPoint® and Excel® instruction.

Table 1
Descriptive Statistics for BUGS and TAMS Science Process Skill Survey

<table>
<thead>
<tr>
<th>Question #</th>
<th>Research Question</th>
<th>Mentor</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>We composed a research question and/or hypothesis statement.</td>
<td>3.68</td>
<td>.716</td>
<td>3.30</td>
<td>.801</td>
</tr>
<tr>
<td>2</td>
<td>We developed a step-by-step procedure that included multiple trials.</td>
<td>3.36</td>
<td>.790</td>
<td>3.55</td>
<td>.605</td>
</tr>
<tr>
<td>3</td>
<td>We developed a list of the materials to be used for the mealworm project.</td>
<td>3.64</td>
<td>.727</td>
<td>3.50</td>
<td>.946</td>
</tr>
<tr>
<td>4</td>
<td>We conducted Internet research to write the introduction to the mealworm project.</td>
<td>2.82</td>
<td>.853</td>
<td>2.65</td>
<td>1.182</td>
</tr>
<tr>
<td>5</td>
<td>We created a data table for the mealworm Project.</td>
<td>3.55</td>
<td>.800</td>
<td>3.45</td>
<td>.999</td>
</tr>
<tr>
<td>6</td>
<td>We took digital pictures or provided diagrams of the experimental setup.</td>
<td>3.36</td>
<td>.727</td>
<td>3.10</td>
<td>1.071</td>
</tr>
<tr>
<td>7</td>
<td>We made graphs for the data we collected from the mealworm experiment.</td>
<td>3.41</td>
<td>.734</td>
<td>3.40</td>
<td>.940</td>
</tr>
<tr>
<td>8</td>
<td>We used observations and inferences to draw conclusions about the results of our experiment.</td>
<td>3.55</td>
<td>.739</td>
<td>3.50</td>
<td>.761</td>
</tr>
<tr>
<td>9</td>
<td>I am pleased with the results of my (mentee’s) mealworm project.</td>
<td>3.36</td>
<td>.790</td>
<td>3.60</td>
<td>.754</td>
</tr>
<tr>
<td>10</td>
<td>I (My mentee) understand(s) the scientific process.</td>
<td>3.45</td>
<td>.800</td>
<td>3.60</td>
<td>.598</td>
</tr>
</tbody>
</table>

*A four-point Likert scale was used (1 = strongly disagree; 2 = disagree; 3 = agree; and 4 = strongly agree). N = 25*
Upon completion of instruction on the use of PowerPoint® and Excel®, each of the participants was given a “Check Sheet for Independent Investigations” to initially guide the development of the presentation and to self-evaluate the completed presentation prior to submission (Figure 2). Each mentee was given access to a computer and digital camera as technologies that could be used to create presentations. As previously stated, the role of the TAMS mentor was that of a guide giving help when asked for it. Each 4th or 5th grade girl was able to navigate PowerPoint® by herself, find clip art using the Internet, insert clip art, make digital pictures, create graphs in Excel®, use design templates, and use slide transitions in PowerPoint®.

Two science experts independently scored completed presentations. A third expert was used to resolve any resulting differences that arose during the scoring process. An exit interview was conducted with twelve randomly selected mentors and mentees regarding their participation in the project.

CONCLUSION

Twenty-five mentors and mentees completed the yearlong after school program. Over the year, a variety of learning snapshots were used to assess and improve the quality of the curriculum, the mentoring skills of the TAMS participants, and the knowledge and dispositions of 4th and 5th grade girls toward science.

Videotaped lessons showed mentor/mentee interactions involving the use of probing questions such as “how” or “why” as opposed to traditional dichotomous questioning techniques involving single-word responses. The videotaped lessons clearly show the BUGS girls were given the opportunity to seek solutions and opportunities for discovery on their own within a relationship characterized by competence, nurturing and respect. Participants were consistently engaged in the learning process as demonstrated in the videotaped lessons and supporting documentation provided from the onsite science consultant.

Since one of the learning expectations of the mealworm curriculum was to improve science process skills, mentors and mentees were asked to independently respond to a Science Process Skill Survey following completion of the mealworm unit. The survey results were used to describe perceptions of the TAMS mentors and the BUGS participants regarding acquisition of science process skills by comparing the extent of agreement between mentor/mentee responses. In general, Table 1 shows both mentors and mentees indicated either agreement or strong agreement with survey questions concerning technology and the mastery of science process skills (e.g., writing
a research question, hypothesis, made graphs). Question #4, conducting Internet research was the only survey question indicating a trend toward mentor/mentee disagreement. The mean response for Question #4 was 2.65 and 2.82 for the mentees and mentors respectively.

<table>
<thead>
<tr>
<th>Science Process Skills</th>
<th>Present ✓</th>
</tr>
</thead>
</table>
| I. Stating a problem to investigate  
  Problem phrased as a research question  
  If...then hypothesis statement |           |
| II. Developing a procedure  
  All steps in sequential order and reproducible  
  Multiple trials indicated  
  Materials are appropriate and described |           |
| III. Gathering data  
  Data organized in table or chart  
  Data has a title  
  Labels for manipulated & responding variables  
  Units are stated  
  Multiple trials, totals and averages are included |           |
| IV. Graphing data  
  Appropriate graph type used  
  Appropriate scale, range, and interval are used  
  Graph has a title  
  Descriptive label for variable on the x-axis and responding variable for the y-axis  
  Graphed data matches data collected  
  Units indicated for each axis |           |
| V. Data analysis  
  Results from graph clearly stated  
  Inferences made about results |           |
| VI. Conclusion  
  Conclusions based on results and inferences  
  Hypothesis is restated  
  Hypothesis is accepted or rejected |           |

**Figure 2.** Check Sheet for Independent Investigations

In addition to demonstrating knowledge of science process skills, a second learning expectation of the mealworm unit was to increase technology proficiency of the BUGS participants. Each girl was provided with four hours of training by a technology specialist in order to master selected features of PowerPoint® and Excel®. These technology skills were embed-
ded in the mealworm curriculum and assessed in the form of a final PowerPoint® project (Figure 2). It is interesting that although participants were provided with a check sheet for independent investigations at the beginning of the mealworm unit, and mentors were aware this checklist would be used to assess understanding of science process and technology skills, a number of process skills were not adequately represented in the final projects. A review of the PowerPoint® presentations show low use of science process skills with regard to including multiple trials (36%); utilizing data tables (52%); graphing (72%); and analysis activities including observations and inferences (44%). Table 2 shows the frequencies and percentages for technology and science process skills used in the PowerPoint® presentations.

### Table 2
Technology and Science Process Skills Included in Mentee PowerPoint® Presentation. N = 25

<table>
<thead>
<tr>
<th>Description</th>
<th>Percent</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clip Art</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>Digital photo(s)</td>
<td>48</td>
<td>12</td>
</tr>
<tr>
<td>Slide transitions</td>
<td>36</td>
<td>9</td>
</tr>
<tr>
<td>Introduction</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Research Question</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>92</td>
<td>23</td>
</tr>
<tr>
<td>Material list</td>
<td>96</td>
<td>24</td>
</tr>
<tr>
<td>Procedures</td>
<td>88</td>
<td>22</td>
</tr>
<tr>
<td>Multiple Trials</td>
<td>36</td>
<td>9</td>
</tr>
<tr>
<td>Data table</td>
<td>52</td>
<td>13</td>
</tr>
<tr>
<td>Excel graph</td>
<td>72</td>
<td>18</td>
</tr>
<tr>
<td>Analysis</td>
<td>44</td>
<td>11</td>
</tr>
<tr>
<td>Conclusion</td>
<td>92</td>
<td>23</td>
</tr>
</tbody>
</table>

In an effort to understand differences between what participants indicated they understood about science process and technology skills compared to what they evidenced in the PowerPoint® presentations, the anecdotal evidences collected during interviews with the participants were reviewed. The interviews suggest a lack of time may have been a factor leading to omission of important process skills that would occur in the later stages of the learning experience. Some mentors indicated that including both a data table and
graph seemed redundant. This comment was interesting in that the mentors are high achieving females participating in a math and science academy for gifted students who have significant experience writing laboratory reports related to science coursework. Still other anecdotal evidence indicated the BUGS girls might not clearly understand the difference between an analysis and a conclusion suggesting an area warranting further research.

In conclusion, a mentored learning experience can provide girls the opportunity to explore science in a supportive, sensitive, and caring environment not always present in today’s classroom. Characteristics such as inquisitiveness, competitiveness, and thoughtful reflective behaviors can and should be encouraged if we are to increase female participation in nontraditional careers such as science and technology. Only with significant support will females be equipped with the strategies needed to cope in traditionally male-dominated careers. Programs such as Bringing up Girls in Science (BUGS) provide female budding scientists the opportunity to increase knowledge about science and develop science process and technology skills requisite to meaningful research investigations.

References