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Drawings as a Component of Triangulated Assessment

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Action research (AR) in an educational setting as described by Tillotson (2000) is an approach to “classroom-based problems” or “specific school issues” (p. 31). His process involves identification of the issue or problem, development and implementation of an action plan, gathering and interpreting data, sharing the results within the community, and “action planning” as a cyclical endeavor (Tillotson, 2000, p. 32). AR is utilized as a key component of developing pre-service teachers in the University of Michigan-Dearborn certification program. Illustrating the five components of Tillotson’s approach, pre-service elementary teachers develop and analyze pre-assessments of K-8 student knowledge about a specific science topic to identify prior student understanding; they create and teach two lessons to provide applicable scientific content, post-assess to determine the impact of their teaching and write a research journal style report describing their project. The AR assignment is more structured than a typical action research project in order to support the pre-service teachers, many whom have never conducted a literature review, created assessments linked to research, or completed an AR project (Luera & Otto, 2005).

Periodically, the capstone course instructors meet to reflect on: trends seen in pre-service teacher learning, needed changes in the course to better serve student learning/understanding, and incorporating new knowledge from the field of research. In many ways, the faculty conduct AR informally on the capstone course. For example, over time a series of pre-writing assignments linked to

components of the AR final report were implemented because of deficiencies identified in student writing (Everett, Luera, & Otto, 2008). Also, a three-circle Venn diagram was created to introduce pre-service teachers to pedagogical content knowledge (PCK) to enable them to better plan their lessons (Otto & Everett, 2012). In our most recent discussion, one author explained an approach to pre-assessment requiring triangulation of multiple sources of data. Another author realized that some pre-service teachers did use multiple sources of data even though it was not specifically required. During this same meeting, it was also noted how drawings as a form of assessment elicited K-8 student knowledge on a variety of science topics. As a result of this conversation, the faculty decided to carefully analyze the pre-assessment measures involving drawings that the pre-service teachers used as a means to assess the quality of information obtained through this strategy and how drawings were used in conjunction with other forms of assessment. The benefits of this analysis may lead to more defined ways that pre-service and in-service teachers may gain useful knowledge from the evaluation of drawings and use of triangulated data in developing assessments in the scope of AR.

Method

At the beginning of the term the pre-service teachers were taught about the goals and objectives of AR and how individual AR projects were to be conducted. A brief discussion on assessment was held during

which the pre-service teachers recognized the need for assessments to be reliable and valid. As a means to increase reliability and validity, triangulation of data described by Creswell and Plano Clark (2006) which facilitates an “across methods type” of triangulation (Denzién, 1978, p. 302) was introduced to the students. This type of triangulation cross validates qualitative and quantitative data, and provides more accurate results, subsequently strengthening the study (Patton, 2001) and controlling bias (Mathison, 1988).

An essential part of supporting the pre-service teachers in developing AR projects is helping them become part of the research community. They are introduced to the use of electronic data bases to identify research articles. The review of the literature is designed to inform the development of assessments for the science lessons. The culmination of the AR project is a formal report written in the style of an educational journal article. Some students have presented results at regional undergraduate research forums.

In this action research study of the capstone course, 24 final AR reports from capstone courses offered between Fall 2009 through Winter 2011 were examined to determine the kinds of pre-assessments administered. The AR projects covered in these final reports included all grade levels, kindergarten to sixth grade; each project was conducted in a different local school. All of these schools are located within a large, diverse metropolitan area with correspondingly diverse socio-economic levels.

Results and Discussion

From this research, the most prevalent forms of pre-assessment were combinations of: Know/Want to know/Learned (KWL) charts administered as either a classroom discussion or as an individual student paper and pencil survey, drawings, paper and pencil questionnaires in the format of a short quiz, or performance assessments such as demonstrating an ability to categorize a group of objects. Although this research indicates the pre-service teachers used a variety of assessment methods, the investigators were

most intrigued by pre-service teachers' use of triangulation, incorporating drawings in combination with other types of assessments such as paper and pencil surveys.

In the following discussion, drawings as assessment tools are described and then contextualized within the scope of triangulating assessments. As the data are nestled contextually within multiple science topics, the results and discussion are explored simultaneously in the text below.

Using Drawings for Assessment

In reviewing the final AR reports, drawings were a component of 17 assessments covering a number of different science topics. For example, in the life sciences, elementary students were asked to draw a picture of a mealworm or a butterfly while in earth/space sciences, the focus of the drawing was on the Earth, Moon and Sun to demonstrate phases of the moon or the order of planets in the solar system. In physical sciences, drawings included the shadows of objects, how magnets work, and objects in different states of matter. An important part of analyzing the drawings as assessment is the nature of the prompt given by the pre-service teachers to the elementary students. For example, a pre-assessment which asks students to draw the life cycle of a butterfly or a mealworm may reveal less information than a pre-assessment question about what happens to the caterpillar or mealworm as it gets older. Some students might not know what a life cycle is, but if asked to draw what happens to the mealworm, the drawing may reveal student knowledge, or lack thereof, of metamorphosis. In this case, students might draw the pupa (the next stage in the insect's life cycle) thus demonstrating knowledge of metamorphosis or they might draw a larger mealworm suggesting that the students think in terms of mammalian growth cycles. Thus, the prompt for the drawing is crucial in eliciting prior knowledge that is not dependent on memorized vocabulary.

Another theme found in the analysis was that drawings provide an opportunity to detect the presence of misconceptions, and the prevalence of the misconceptions among children in a

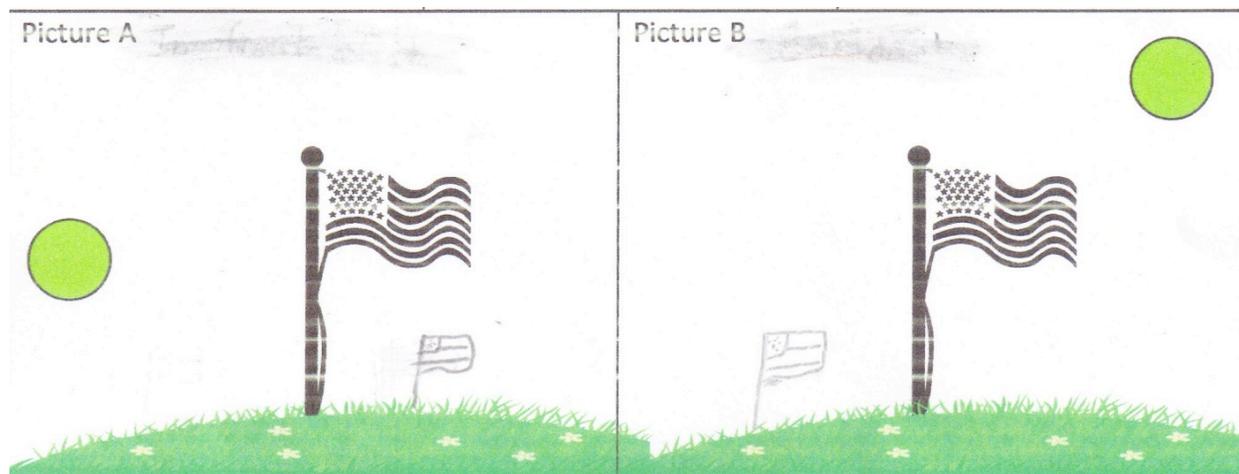


Figure 1. Student drawing of shadows cast by a flagpole with the sun in two different locations.

particular classroom. For example, a group of pre-service teachers asked students to draw the shadow cast by a flagpole. More than half of the students drew shadows that had stars and stripes. The drawings indicated that students had the misconception that a shadow would have the same image details as the object itself, while another misconception was that the shadows were objects unconnected to the flagpole (Bawol, Gubbini, Hawrylak, & Otto, 2012)¹. Figure 1 is an example of a student drawing showing both the presence of stars and stripes in the shadow as well as showing the shadow as a separate object.

A different example of identifying nonscientific conceptions occurred when some pre-service teachers asked second grade students to draw a plant. They found that almost all the children drew flowers on their plants; out of 24 students, 18 drew large flowers, 2 drew small flowers and 3 drew a plant without flowers and only 1 drew a tree. The misconception that all plants have large colorful flowers appears very early (Kose, 2008).

The four pictures in Figure 2 illustrate a number of misconceptions about plants in addition to the presence of large flowers. The second grade students illustrated three

different locations for the seed: in the ground (8 students), in the flower (3) and on a root (1) and the remainder did not draw any seeds. These same students also drew three different root systems: one student drew carrot-like roots, 7 drew branched roots and 16 drew roots either as straight or wiggly lines. Fourteen students did not include fruit on their drawings but the 10 students who added fruits to their drawings all drew fruits resembling cherries. Only one student connected the fruit to the flower and this student's drawing suggested that both the fruit and the flower could exist simultaneously. If the children had been given a drawing of a plant and asked to name the parts, the concept that plants usually had flowers would not be revealed nor would they reveal the mixed views on fruit and fruit location, seed location or type of root structure. The conceptions of a plant as illustrated by the second graders are not necessarily incorrect but neither do they demonstrate complete understanding. Therefore, using a second type of assessment as discussed below in Triangulation, leads to implementing additional tools for assessing student thinking.

One example of connecting a drawing to content occurred when students drew what they thought a mealworm would look like. The drawings revealed how some students thought the mealworm was more like a worm with no legs, or a millipede with many legs, or like an actual larva with six legs. In the absence of a

¹ The results described here were obtained by students conducting their action research projects. In this case, their work was published.

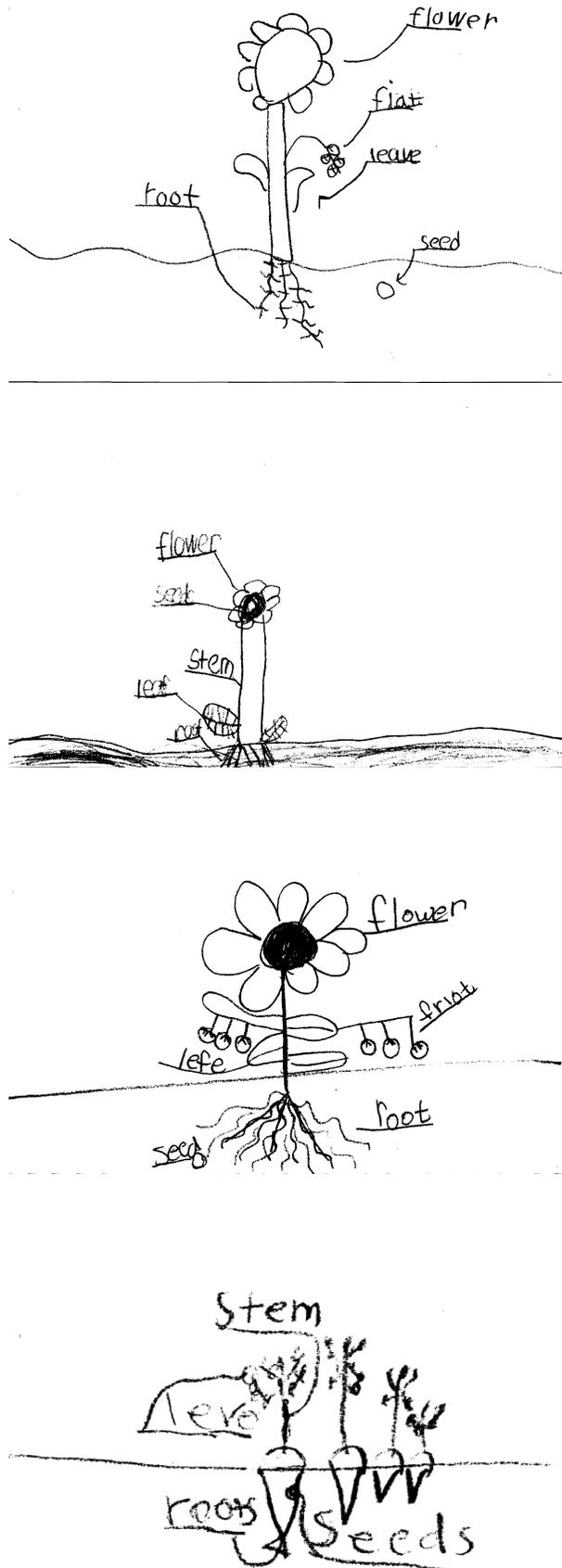


Figure 2: Student drawings of plants

drawing, it would be impossible to determine what children think unless a specific question about the number of legs was asked. (This also highlights the importance and value of triangulation, where drawing a mealworm without legs could be interpreted as thinking that a meal worm was like a worm or it could be interpreted as a lack of time to include details on the drawing.) Similarly, a drawing of a butterfly would reveal if children understood that a butterfly does not have a mouth for eating but only a proboscis for drinking.

Benefits to using drawings are perhaps more apparent for early elementary students who are able to express considerably more content knowledge through a drawing, than by writing or through a discussion (Kose, 2008). For example, pre-service teachers asked early elementary students to draw water as ice and as liquid. Children drew an ice cube and a puddle of water but were not able to describe these states of water in words due to lack of relevant vocabulary. Another group of pre-service teachers asked first grade students to draw a liquid and a solid object. They reasoned that first graders would be able to represent their understanding of solids and liquids through drawings better than through writing. Analysis of the elementary student data revealed that the students knew liquids take the shape of their containers while solids do not. One more benefit to the use of drawings is that the analysis can be completed quickly; in some cases, analysis can be conducted while children are drawing. Rapid analysis is favored when looking for the presence or absence of a specific misconception. For example, an assessment by pre-service teachers that asked sixth grade students to show the position of the Earth and Sun in each of the four seasons was quickly analyzed for the correct tilt of the Earth's axis. Teachers can easily determine if students draw the Earth with the axis pointing in the same direction for each season or if the axis points in different directions as the Earth orbits the Sun.

Triangulation

Often, the pre-service teachers' first reaction to the use of triangulation was that the

assessment would need to be long and arduous both for the elementary students and for themselves as they administered and then analyzed the data. Once it was explained that the assessments for the elementary school students could include multiple types of data, pre-service teacher anxiety was reduced and many of the pre-service teachers developed, administered, and analyzed data from multiple types of assessments. A number of the pre-service teachers triangulated their data sources into three broad types of data in a manner similar to that described by Philips and Carr: “(1) observations, (2) interviews and (3) artifacts/documents” (2010, p. 74). For instance, several pre-service teachers demonstrated their understanding of triangulation by creating projects in which the elementary students completed part of the assessment via a paper and pencil survey, part as an interview, and another part using drawings.

Most of the pre-service teachers recognized the need to distinguish between assessing students' science content knowledge and their writing and verbal abilities. This was attributed to the fact that many of them have experiences in English Language Learner (ELL) classrooms and have developed a heightened awareness of the complex interplay between language and the ability to understand science content and communicate science content accurately. It was the pre-service teachers' belief that a single assessment would not necessarily capture the knowledge of these students. For example, the pre-service teachers became aware of potential difficulties with English and/or reading levels during discussions with the classroom teacher. As a result, pre-service teachers then elected to interview a sample of students as another method of formative assessment to supplement the survey completed by the entire class in order to obtain a better understanding of student knowledge.

An example of this method of triangulation is illustrated by a group of pre-service teachers who asked a classroom composed primarily of ELL students to write their definition of a scientific model, draw an example of a model, and explain verbally what their drawing

represented and why they thought the object was a model. One of the pre-service teachers described the difference between what the students could communicate in writing compared to what they could communicate verbally:

The children in this class seemed to understand English well, and yet we learned quickly that some of them responded very differently (more accurately) to questions asked in Arabic (language spoken at home for many of these children) than to those asked in English. Our team considered this to be highly significant, particularly since the aforementioned students seemed to, in conversation, speak and understand English well. ...perhaps what can sometimes be perceived as lack of knowledge or misconceptions is actually a language issue.

Drawings for young elementary children, particularly in grades K thru 2, are in some ways more beneficial for determining individual knowledge than class discussion where young students may 'follow the leader' in agreeing with answers provided by others rather than expressing their own understanding. In a pre-assessment administered to kindergarteners, students were asked to draw the appearance of trees in each season in Michigan. During the assessment, one student asked how to draw a snowflake. The pre-service teachers demonstrated to the entire class how to do this and then observed that some children drew snowflakes in inappropriate seasons. In an informal interview, these children said they knew the snowflakes did not belong in that season but they liked drawing them.

Multiple assessments provided more information about children's thinking than paper and pencil questions alone. In a pre-assessment intended to elicit third graders' understanding of shadows, both an individual KWL chart and drawings of shadows were employed. In the KWL portion, many students revealed an understanding that both a source of light and an object were required for a shadow to be seen but the shadow drawings revealed confusion about where the shadow was located relative to the source of light and

the connection between the object and the size of the shadow (Bawol, Gubbini, Hawrylak, & Otto, 2012). Thus, some students drew the shadow between the light source and the object, some did not connect the shadow to the object casting the shadow and some did not recognize that the length of the shadow would change depending on the location of the light source. (See Figure 1.)

In another example, pre-assessments were developed to elicit first graders' understanding of the tooth structure of herbivores and carnivores. Pre-service teachers created a paper and pencil questionnaire in which students were asked to draw the teeth of a cow and a tiger and what each of these animals eats. Several students were also interviewed individually in a second part of the pre-assessment. The interview questions probed similar understanding of teeth but were not identical to the questions on the paper and pencil survey. For example, the first two questions asked students if their teeth were different or the same as a tiger's and for their reasoning. In analysis of both pre-assessments, the pre-service teachers concluded that the first grade students had a simplistic understanding of the connection between tooth structure and diet and thus one of the lessons taught was devoted to exploring this relationship.

Another group of pre-service teachers taught a group of second and third graders about the states of matter using scientific models. The elementary students were pre- and post-assessed using pictures and a written survey that had sections for constructed responses and matching items. On the post-assessment there was an increase in the number of students who were able to identify pictorial models of, and choose the correct label for, liquids in different states, yet there was a *decrease* in the number of students who could correctly write a definition of a scientific model. By triangulating the data and having multiple forms of assessment, these pre-service teachers were able to conclude that students used scientific models to understand the science concept, yet were still unable to articulate the tool (models) they used to learn the concept. They concluded that more instruction was

needed about scientific models. Triangulating the data, in addition to increasing the validity of the findings, provided an authentic way for the pre-service teachers to experience the complexity of data analysis and the difficulty of formulating conclusions about the impact of their teaching. They were often surprised that the data was 'messy' and difficult to interpret, which we believe is an experience that our graduates are likely to encounter once they have their own classroom.

Implications

Pre-service teachers who connected their assessments to prior research were able to obtain deeper insights into K-8 student understandings and their analyses were more robust and thoughtful. Rich information was obtained from the pre-assessments that included drawings but more guidance from course instructors would improve both the pre-assessment itself and the subsequent analyses. For instance, many groups of pre-service teachers learned that *how* assessment questions are asked has a large impact on the students' responses. One example is a group that asked third grade students to list the functions of a plant stem. The pre-service teachers were surprised that nearly all of the third graders listed only one function. After they consulted with the classroom teacher, they discovered that the wording of the question was not clear to the class of primarily ELL students. The pre-service teachers adjusted the post-assessment question to request a specific number of functions. They concluded that the results were a more valid reflection of the third graders' knowledge. Recognizing the importance of wording in an assessment was a significant learning experience for this group of pre-service teachers.

As a result of the analysis performed, the faculty intend to emphasize the need to triangulate assessment data as a component of all future AR projects conducted by the pre-service teachers. In addition, the benefits of using drawings as a way to assess student understanding in all grade levels will be stressed.

For in-service teachers, the recommendation is to not only measure student knowledge by use of multiple methods, (i.e., triangulating assessment data) but also to employ drawings as a means of assessment. For many, drawings are typically thought of as 'art' rather than as a cognitive task.

Drawings in science are useful for students, in particular young children and ELL students, as a way to convey their understanding or their mental models of a science topic in a way that words cannot. Teachers should gain familiarity with literature on students' understanding of science topics in order to become aware of common misconceptions that elementary students possess. This literature would be useful in formulating new assessments as well as potentially providing tested assessment methods.

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References

- Bawol, A., Gubbini, A., Hawrylak, H., & Otto, C.A. (2012). Third graders' knowledge of shadows. *MSTA Journal*, 57(1), 27-31.
- Creswell, J.W. & Plano Clark, V. LP. (2006). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage Publications.
- Denzin, N. K. (1978). *The research act. (2d ed.)*. New York: McGraw-Hill.
- Everett, S., Luera, G.R., & Otto C.A. (2008). Improving pre-service elementary teachers' writing in a science context. *Journal of College Science Teaching*, 37(6), 44-48.
- Kose, S. (2008). Diagnosing student misconceptions: Using drawings as a research method. *World Applied Sciences Journal*, 3(2), 283-293.
- Luera, G.R. & Otto, C.A. (2005). Development and evaluation of an inquiry-based elementary science teacher education program reflecting current reform movements. *Journal of Science Teacher Education*, 16, 241-258.
- Mathison, S. (1988). Why triangulate? *Educational Researcher*, 17(2), 13-17.
- Otto, C. & Everett, S. (2013). An instructional strategy to introduce pedagogical content knowledge using Venn diagrams. *Journal of Science Teacher Education*, 24(2), 391-403.
- Patton, M. Q. (2002). *Qualitative evaluation and research methods (3rd ed.)*. Thousand Oaks, CA: Sage Publications, Inc.
- Phillips, D. & Carr, K. (2010). *Becoming a teacher through action research: Process, context, and self-study*. New York, NY: Routledge.
- Tillotson, J. W. (2000). Studying the game: Action research in science education. *The Clearing House*, 74, 31-34.