Restructuring higher education class format to better prepare future teachers to offer hands-on science learning to their students

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Abstract

Many traditional university-level science classes consist of multiple hours of lecture each week accompanied by a two-hour, hands-on laboratory session in which participants use high-tech equipment to explore the world around them. However, this model does not align with the typical elementary classroom schedule, and thus, it does not adequately prepare future teachers to be successful at providing hands-on experiences for their students. A typical elementary teacher cannot dedicate a two-hour block each week for their students to perform science experiments, and public schools often cannot afford high-end science equipment. Thus, there is a disconnect between how universities are preparing future science teachers and the reality of the day-to-day elementary classroom. This disconnect can be addressed by restructuring the college science classroom to more closely mirror the elementary classroom, not in content but in time format. At Dickinson State University, science courses for future teachers have been adjusted to meet one hour a day for five days a week rather than three lectures a week plus a two-hour lab. This provides the same amount of time to teach content, but the lab times have been broken into two shorter lab days. These one-hour lab sessions allow future teachers to experience more hands-on labs which can be completed in a shorter amount of time, and they provide those teachers a wealth of classroom activities which can easily be converted to the elementary classroom. Beyond a shift in time scheduling, Dickinson State University has also re-organized the equipment used in these labs. Rather than offering labs using equipment that will rarely be found in a public school classroom, the labs have been adjusted to make best use of simplified equipment that is reproducible by future teachers in their own classrooms. This allows for direct transferability of skills between the university classroom and the elementary classroom. While every change in teaching format can pose its own challenges, these alterations are already producing positive results. The education majors completing these classes tend to be more excited about teaching science in their own classrooms, and they are more comfortable with the hands-on activities that are available to them. The new format is also providing a richer opportunity for the college instructors to model correct scientific thinking and experimental design skills that are specifically applicable to future elementary classrooms.

Restructuring Higher Education Class Format to Better Prepare Future Teachers

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Overview:

The traditional lecture/lab format in university science courses may be providing the necessary science content knowledge for teacher education students, but it often does not prepare those students with the pedagogical skills that they will need to transfer that learning into hands-on, accessible science lessons for their future elementary students. Several problematic issues have been identified:

- Class format at the university level does not match the time segments available for science activities in an elementary classroom.
- University labs often emphasize science content knowledge but do not promote experimental design knowledge. However, the U.S.'s Next Generation Science Standards (NGSS) expect teachers to focus on these process skills with their own students.
- Complex equipment used in a university science lab is typically not available for use in the elementary classroom.

These disconnects between the university learning experience and the expectations for elementary teachers often result in graduates from teacher education programs feeling ill-prepared to offer hands-on science to their future students. As a result, the fallback choice for many of these teachers is to simply avoid teaching science as much as possible.

Dickinson State University has chosen to directly address these deficiencies by redesigning its Physical Science course to more closely mirror elementary school schedules and learning expectations. This course provides elementary education majors with a solid background in physics, chemistry, earth science, and space science content while also focusing on science process skills.

Problem 1 – Class format:

<u>There is a disconnect between the formats used to teach science at the university level and at the elementary school level:</u>

- Typical university science courses in the U.S. consist of:
  Three 50-minute lectures each week
  One 2-hour lab each week
- Typical elementary school classes meet five days a week with science being addressed in 20-40 minute blocks over the course of the week.
- Future teachers who learn their hands-on science in university labs often struggle to convert those two-hour experiences into a shorter format that is appropriate for the elementary classroom.

Solution 1 – Scheduling change:

Changes were made to Physical Science, a course designed to provide future elementary teachers with the necessary background in physics, chemistry, earth science, and space science.

- The course format was altered to more closely mirror the elementary school week. The class now meets five days a week for 50 minutes each day.
  Three 50-minute lectures each week
  Two 50-minute labs each week
- Students are exposed to hands-on labs that can be done in shorter amounts of time. This prepares the future teachers with a large number of labs and activities that can be done in a time frame that is reasonable in an elementary school classroom.

Problem 2 – Lack of focus on science process skills:

<u>There is a disconnect between the content taught in labs and the science process skills that teachers are assumed to have:</u>

- Many university science labs focus on an understanding of the science concepts being taught in the lecture course.
- However, the U.S.'s updated Next Generation Science Standards place an equal emphasis on elementary students learning content and science process skills. Students are expected to be able to demonstrate skills such as:
  * Making observations & drawing conclusions
  * Identifying independent and dependent variables
  * Designing and conducting simple experiments
  * Collecting and accurately reporting data
- If elementary education majors are exposed only to pre-designed, instruction-heavy labs, they themselves do not have the necessary science process skills. When teachers do not have the skills, they are not comfortable trying to teach those skills to their students.

Solution 2 – Lab format change:

Labs in the Physical Science course have all been re-written. Three distinctive types of labs have been created to address the variety of learning objectives that now exist for the class:

1) Many of the labs ask the students to design their own experiments (with instructor guidance) to learn about the current content under discussion while focusing on experimental design. (see lab example below)
2) Some labs are focused on students working through various station activities, each lab focusing on one or two science process skills (ex. observations and data collection) while still providing content knowledge.
3) Some labs are more traditional, offering step-by-step instructions with a focus on learning the science content knowledge.

- By focusing as much on the science process skills as the science content, the elementary education majors are better prepared to teach these same skills to their future students.

New lab example:

<u>Experimental design – Cloud in a jar</u>

- Students walk through an activity where they make a cloud in a jar:
  1 cm of hot water is placed in a 600 mL beaker.
  A lit match is dropped into the beaker and a bag of ice is placed over the top.
- Students then brainstorm variables that could be changed in the activity.
  Ex. temp of water, size of beaker, number of matches used, …
- Each pair of students chooses a single variable to alter and then designs an experiment. The instructor approves the experimental plan before the students begin working.
- Students perform their experiment and gather data.
- Students record their experimental procedure, data, and conclusions.
- Each group's conclusions are shared with the class as a whole. This allows the class to discuss which variables affect cloud formation and which ones do not.

This type of activity models for the education majors how they can teach science in their future classrooms.

Problem 3 – Laboratory equipment:

<u>There is a disconnect between the equipment used in university science labs and the equipment available to elementary teachers:</u>

- University science labs often ask college students to perform multi-part science experiments using specialized laboratory equipment.
- Typical elementary schools do not have the funds to buy expensive, dedicated science equipment nor is that equipment age-appropriate for elementary students.
- Future teachers who complete their university science labs using this more complex equipment are often unprepared to offer hands-on experiments for their future students given the limited equipment budgets available to most schools.

Solution 3 – Equipment change:

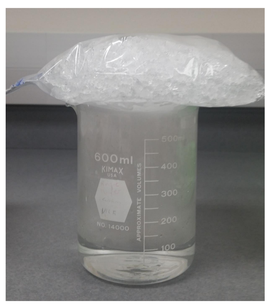
- All the labs in the Physical Science course have been altered to use equipment that is low-cost and readily available to teachers.
  * Labs have been adjusted to use simpler, less-expensive science equipment or supplies that can be easily purchased from local stores.
  * Labs that require expensive, university-level equipment have been replaced.
- Students have practice doing hands-on experiments with equipment that they will have easy access to when they are teaching.
- Future teachers will be prepared to run experiments using equipment that is age-appropriate for their students.

Results:

After teaching the Physical Science course for three years using this new format, it has been observed that:

- Teacher education majors are gaining hands-on experience that helps them learn both the science content knowledge and the necessary science process skills to be effective elementary science teachers.
- Teacher education majors are exposed to a plethora of hands-on activities that are directly transferrable to their future teaching.
- After completing a semester of instruction, teacher education students report that they are more comfortable with the idea of teaching science.
- Teacher education majors who complete the adjusted Physical Science course and then go on to do their student-teaching experience often return to campus and report that the kids in their elementary classrooms said science was their favorite school subject because of its hands-on, interactive nature.

Experimental setup for the "Cloud in a Jar" activity.



"Cloud" forming in a beaker.

Photography encouraged