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An evaluation of the effectiveness of peer-directed, problem based biotechnology lessons on students’ confidence in real-world problem solving and on their higher level thinking in science.

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Abstract

Traditional teaching in science classrooms has been a primary method of instruction with limited success. Students do not obtain a deep understanding of the science concepts and do not develop the confidence necessary for solving real world problems. Peer-directed, problem based biotechnology oriented approach to science allows the students to develop higher level thinking, deeper understanding, and therefore increased confidence to approach problems in a new and innovative ways. The problem base learning, while lauded by many educators, is not a prevalent mode of teaching in the science classrooms. Some educators might be trying to implement only some aspect of problem base learning, (such as, introducing more labs and providing articles to read) which unfortunately will not provide the tools necessary for students’ success. This paper will introduce a better problem base biotechnology approach which will require the teachers to reduce the lecture time by half, providing virtual labs and discussion during and after practical labs. The lecture should be conceived and planned to incorporate students’ participation by introducing students to specific real life problems or case studies that allows the students to conceptualize problems, and give the students confidence to undertake solving problems. The focus is on a learner-centered investigation where students are engaged in authentic scientific inquiry. The students need to be prepared ahead of time with the vocabulary as well as the methodology of a lab prior to experimentation. This is achieved through introduction of virtual labs. Allowing the students to familiarize themselves with the labs and obtaining a higher level of achievement during the practical lab. During and after labs training the students will not to merely focus on the specific issue at hand but also think more expansively about alternative solutions and hypothetical alterations. By implementing simple methods of problem base learning students will show an increase in their deep understanding of science concepts and higher level thinking which in return will increase the students’ confidence toward solving real world problem.

Rationale

After many years of teaching Science classes, I have come to the realization that many students lose concentration during long lectures. The students’ learning becomes more of a memorization rather than deep understanding which can lead to higher level of thinking. Traditional lecturing is one of our primary methods of instruction with the benefit of reaching large groups of students (Costin, 2006). It is particularly beneficial for presenting summaries of theories or facts, analysis, supplementing and expanding information beyond the textbook, and background information on labs or essential materials necessary for student to perform labs. While a lecture can be beneficial, it cannot help students in becoming active learners. Most teachers use the recitation approach in their lecture, which delegates the responsibility of solving problems to the teacher, making the classroom more teacher-centered, leaving the students with the responsibility of only providing answers to discrete steps (Webb, 2004). “Many of us have been taught by lecture and view it as safer, easier, and more reliable than other methods of instruction” (Wylie, 2011, p.26).
But lectures traditional as well as power point should not be the only way that teachers transfer knowledge. A lecture should be conceived and planned to incorporate students’ participation by introducing students to specific real life problems. Allowing time for students to understand the problem, and helping the student preferably in a group to discuss the problem and find solutions in a guided design. The role of a teacher becomes more of a coach and guidance than traditional teaching. Allowing the students to make mistake and learn from them. The cooperative group work should be set up to promote students’ response to one another’s ideas, create products and results together, and teach each other. Students are also required to conduct labs; however, many students follow lab instructions blindly and without fully understanding the concept behind the lab work. Therefore the students will start lacking the development of higher level thinking and problem solving. There are three cognitive approaches to instruction and learning: learning as response acquisition, learning as knowledge acquisition, and learning as knowledge construction. These three methods of learning allow the role of the learner to switch from a passive learner to a more active decision maker. It also allows the teachers to abandon their roles from a dispenser of rewards and punishments to a guide for understanding academic tasks. Therefore the teacher can become a facilitator in helping students make sense of material by promoting discussion and supervised participation in meaningful activities (Sudzina, 1997). The objective in this research is to diminish teacher lead lectures and promote small and large group discussions, article analysis, cooperative learning, and case studies. The teacher will be still lecturing but the lectures are used in combination with other types of instructions. Instead of old fashion lectures the teacher should provide real-world examples to illustrate the textbook's concepts; promote class discussions, follow-up with lab sections or readings to provide hands on experience, and even present conflicting interpretations of a subject to promote further analysis and discussions. Lectures can also be used to provoke students to think beyond simply taking notes and writing down facts. It can entice the students to engage in the higher-order skills of critical thinking. Lectures also provide an opportunity for teacher to share their knowledge and training with their students through modeling a solution to a problem, illustrating a point with specific research, or demonstrating aloud how to analyze a text or problem. After offering such demonstrations a few times, students will be able to practice and experiment on their own and make sense of their own findings (Wylie, 2011). After the introduction of the lesson in multiple ways including smaller lecture, the students will be given a chance to preview the lab and equipment for the unit by modeling (teacher demo) or using virtual labs. Some virtual labs can produce as much value to a learner as a practical lab since many students have different styles of learning and require different time frame in processing data (Olson, 2006). Virtual labs allow the students to familiarize themselves with the technology, terminology, and methodology necessary to perform the lab. The virtual lab, practical biotechnology labs, and collaborative work between students will allow them to reach higher levels of thinking and raise their confidence in solving real-world problem. Finally, the students are required to solve mock crime scene set ups as a problem based biotechnology learning lab. The students need to work in a small (2-3 per group) and large (5-6 per group) cooperative groups. Students have to use inquiry and higher level thinking to solve problems and use biotechnology tools in the inquiry. There are 3 different ways creating small groups: casual, cooperative, and team-based. Casual use of groups refers to the quick creation in class of student pairs or small collaborative groups (3 is recommended) to discuss a question or solve a problem. This allows students to actively engage with each other and with the material without any previous planning from the teacher. Cooperative learning involves the use
of groups to engage in more structured activities. These activities and groups are usually prepared in advance by the teacher. These activities allow the students to be actively engaged and provide opportunities for problem solving and application of content. Team-based learning involves a further level of structure and intentionality. It requires more time and preparation from the teacher but still allows collaborative work and problem solving in a larger group setting (Olsen, 2011). The students will show their mastery of content knowledge and understanding of technology through problem solving in a real-mock crime scene. The collaborative work in the groups, hopefully, will allow the students to reach a higher level of understanding and critical thinking. Cooperative learning promotes interaction between the students as well as between the student and the instructor, also this educational approach helps students to share responsibility for their own as well as their group academic achievement (Stein, & Hurd, 2000). In an inquiry based approach to cooperative learning the students will be actively engaged in learning and in discussion with their peers (Davidson & Worsham, 1992). Through this active discussion and group inquiry based learning students can achieve higher level thinking and problem solving skills.

The purpose of this study is to evaluate the effectiveness of peer-directed, problem based biotechnology lessons on students’ interest in real-world problem solving, and on their higher level thinking in science.

**Intervention**

I will collect data from one of my Forensics classes at Timber Creek High School. All my classes are Honors level and the students are in majority seniors but I will have some juniors. The data will be collected through 1st and 2nd quarter. The unit that will have the incorporation of Bench to Bedside is on Hair analysis section. **Hair Analysis unit and DNA unit**

(The underlined sentences are the unit incorporated directly from Bench to Bedside program)

- Hair lecture, importance of hair analysis in the field of forensics
- Student learning on structure of the hair relating to its function
- Pre-lab work, comparing different hair structure under the microscope
- Simple lab work, comparing and contrasting human hair to different animal hair
- Problem base learning, finding the identity of an unknown hair
- DNA lecture, review of DNA structure as it relates to its function
- Virtual lab of DNA extraction
- Practical lab of DNA extraction from the roots of the hair
- Small lecture on Restriction enzyme
- Virtual lab on the action of Restriction Enzyme
- Paper lab on Restriction enzyme
- Restriction Enzyme lab
- Small lecture on PCR
- Virtual Lab on PCR
- Practical lab on PCR
- Small lecture on gel electrophoresis
Objectives

- Describe and explain what characterizes science and its methods.
- Identify sources of information and assess their reliability according to the strict standards of scientific investigation.
- Describe and provide examples of how similar investigations conducted in many parts of the world result in the same outcome.
- Scientific method of solving inquiry based problems
  1. pose questions about the natural world,
  2. conduct systematic observations,
  3. examine books and other sources of information to see what is already known,
  4. review what is known in light of empirical evidence,
  5. plan investigations,
  6. use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of data, including data tables and graphs),
  7. pose answers, explanations, or descriptions of events,
  8. generate explanations that explicate or describe natural phenomena (inferences),
  9. use appropriate evidence and reasoning to justify these explanations to others,
  10. communicate results of scientific investigations, and evaluate the merits of the explanations produced by others.
- Recognize that the strength or usefulness of a scientific claim is evaluated through scientific argumentation, which depends on critical and logical thinking, and the active consideration of alternative scientific explanations to explain the data presented

Students will:
- learn to identify different types of roots, tips, disease and colored hair
- learn to identify different types of human hair
- learn to identify different types of animal hair
- learn to differentiate between human and animal hair
- learn how to extract DNA from hair roots
- learn the structure and function of DNA and DNA replication
- learn about the application and uses of PCR
- learn about the procedure required for DNA fingerprinting through gel electrophoresis
- apply their knowledge to solve a real world problem

Teaching Strategies
- Lower the number of days that is set up for a lecture down to two days (instead of 4 days) or 15 minutes/day for 4 days.
• Allowing students to find their own answers through case studies, comparison of articles, and analysis of data.
• Provide pair grouping to compare and contrast the structure of animal vs. human hair
• Provide larger group (3-4) to work on extraction of DNA from the hair root
• Virtual labs on gel electrophoresis and PCR before practical labs
• Biotechnical labs: DNA extraction, PCR and Gel electrophoresis, allowing cooperative work
• Problem base learning lab based on real-world case such as paternity and murder case

Connections to Bench to Bedside Summer Institute

I will use the resources provided by Bench to Bedside program in my classes. I will use the virtual lab on PCR and also other virtual lab recommended by Dr. Darwiche. I will also use the DNA extraction lab, Restriction Enzyme lab, PCR lab and gel electrophoresis lab in my class.

Data Collection and Analysis

Data collection will be done in multiple ways.

Pretests:
---Each unit will have a pretest on vocabulary, content, technology and application. The pretests will be presented in form of a multiple choice and each answer will have a value that students give to their answers base on their level of knowledge and comfort with the subject. The values will be set from 1-5:
1= do not know the answer, I’m just guessing
2= I’m not confident about my answer
3= I’m neutral about my answer
4=I’m somewhat confident about my answer
5= I’m very confident about my answer
---Pretests may also have a sentence agreement portion. The students are not required to answer as True or False but rather as a value to represent their level of knowledge with the subject.
1= I’m confident this is a not a correct statement
2= I think this might be a wrong statement
3= I do not know about this subject
4= I think this might be a correct statement
5= I’m confident this is a correct statement

Tests:
---Each end of the unit test will have a multiple choice section to check for students’ understanding of the subject. This will be compared to the pre-test results and check for student’s academic gain.

---Also each test will have higher level thinking problems, such as word problems or case studies that require higher level thinking and analyzing concepts. The students sometimes will be allowed during this section to look at their notes or even do it with another student in a cooperative work, since it requires analysis rather than memorization. This section will be graded on points based on how complete and thorough the students are solving their problems. These problems will be used in practical settings (mock crime scenes) to check for understanding.

---Lab reports are also part of formal assessment. Looking at the way the experiment was performed, methods, data collection and result will be grade on specific scale provided for each lab. Labs are done in a cooperative small groups (2-4). The analysis portion of the labs will be graded to show higher level of thinking. Earlier labs will have smaller section of analysis but as the school year progresses the analysis section will be more developed and represent a higher level thinking.

Informal Testing:
---Keeping track of the questions asked in class will be done on regular bases. A tally of the 3 types of questions asked during class and after school help time.
Type A= regular, low level questions that require reciting the subject and can be learn through memorization
Type B= mid-level questions, usually starts with How, Where, When and Why and requires a deeper understanding of the subject on the student part and more explanation on the teacher part
Type C= high-level questions, usually it is an analysis question and may have an If or What If in that sentence. This is the type of questions that students may want to experience with in a lab in order to find their own answer and there are not simple solutions to these questions. It requires deep understanding of the subject from the students.

---Group discussions are also part of informal testing. It is important to keep track of student small group discussion and the capabilities of students to join in into large group discussion base on their finding in the small group work. Students will keep records of each other findings and conclusions for each section will be done independently to check for understanding.

---Students’ self-rating about their level of understanding, struggles, progress, satisfaction, and other concerns will be done on monthly bases. These will be done through informal discussion and informal interview. A 5 minutes discussion each month will allow the teacher to discuss student’s progress and struggle; all discussion will be logged into a journal and compared with the grade book to check for progress.

Teacher Journal:

---Journal entry will be done on daily and weekly bases on the methods of teaching, labs and the whole class overall. This is done purely to re-evaluate teaching methods.
Literature Cited


Budget and Budget Justification

Apart from using multiple lockers from the Bed to Benchmark program I will need materials for the labs for 5 other classes that will also be performing the same labs but they are not part of the data collection process.

Gel electrophoresis gel, PCR kit and Restriction Enzyme kit will cost about $1,200.00

Permissions

Permission slips will be required for students’ pictures and video to be used for educational purpose
Permission slips will be required for fingerprinting the students.

Permission slips will be required to remove hair from the roots from the head or body of the students.