Creating Student-centered, Problem-based Classrooms

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Creating Student-centered, 
Problem-based Classrooms

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Introduction

Student-centered, problem-based learning, also known as inquiry-based learning, is a new phrase used to describe an age-old teaching technique. For years teachers have realized that students do not learn at their highest potential when they are in a classroom where the teacher stands at the front of the room and “imparts knowledge”. Students want to get their feet wet and get their hands dirty. They learn by doing, and they learn it even better when they discover it themselves.

Yes, for years TEACHERS have known that this technique works best. So why aren’t we using it in our classrooms more? The answer is fourfold:

a) Administrators have not understood the implications of using student-centered, problem-based learning. In the past, when they entered a classroom they wanted to see the students quietly working on an assignment or the teacher teaching;

b) Parents have not understood the implications of using Student-centered, problem-based learning. When their student comes home and tells them about “what they did in school today”, parents become concerned that they are not using their time productively;

c) Teachers did not know how much difference this would make in their teaching and the students’ learning. Some teachers were not willing to take the extra time required to have a successful student-centered, problem-based learning environment.

d) Students were passive and satisfied with the traditional, at the same time questioning why they had to learn the topic at hand.

This document will address the idea of student-centered, problem-based learning (hereafter referred to as project-based learning), how to establish a student-centered, problem-based classroom and what happens when you do.
What is a Student-centered, Problem-based Classroom?

All of us have a stake in creating a learning environment for students that will enrich their learning experiences, make them enthusiastic learners, and motivate them to pursue excellence in scholastic achievement. It is not only the teachers responsibility to change the way students gain knowledge. But teachers do have a huge responsibility because they are the first point of contact with their students and have a tremendous influence over the way they learn.

National Science Education Standards want Scientific Literacy.
National Educational Technology Standards want to effectively use technology to support PreK-12 education.
Benchmarks for Science Literacy wants to encourage students, from the first day they walk into a classroom, to ask questions, try to find answers, count and measure, make qualitative observations, and analyze.
Alabama Course of Study for Mathematics says “Mathematical power exists when students:
- Value Mathematics;
- Display confidence in their mathematical ability;
- Solve problems;
- Communicate mathematically;
- Reason mathematically; and
- Make connections within mathematics and to other subjects.¹

Alabama Course of Study for Language Arts says “a language arts curriculum must be characterized by certain traits and practices:
1) students must make a genuine connection between an activity and its purpose or meaning;
2) language is learned within language-rich environments where experimentation and risk-taking are encouraged;
3) language growth must be evaluated in a manner that is individualized and meaning-centered, that is compatible with instruction, and that promotes continued growth.²

These standards are minimum requirements. Our goal is to boost literacy to a higher level, a level where students and teachers work together as a team to become scientists, mathematicians, and technical writers and communicators in their classroom, and develop an appreciation and admiration for the subject and the learning process. We all want students to be enthusiastic learners, empowered by and responsible for their learning. Once that is accomplished it will be a new environment in your classroom.

² Allen, Dick; Corones, Jim; Gentry, Edna; Helland, Barb; Summers, Barbara; Zachmann, Dave; Pardee, William, Editor and Facilitator; “Potential Benefits of an Ideal AiS Program”, 1999.
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Students Want It! It!

Teachers Want It!

Parents Want It!

Standards Demand It!
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What is it that they want?

They want a learning environment that promotes not only gaining baseline knowledge but also creating their own knowledge. This can only be accomplished if students become stakeholders in their own learning and the learning process. They must gain the ability to process knowledge rather than only finding or memorizing information. They must be able to make decisions based upon their findings. They must become proficient in problem solving.

These skills can be acquired through a project-based learning environment. This type of learning implies that students will develop inquiry skills and attitudes or habits of mind that enable them to continue the quest for knowledge throughout their life.

The most important outcome in a classroom should be the ability to continue learning and applying skills for learning. Subject matter or course content is important, but why? It is not an end in itself; it is a means whereby students can expand their knowledge and understanding of the things around them. It is better for them to be able to apply knowledge to a new situation than to know the answers to “old” questions. We want students to be content literate, but also have a sense of enthusiasm about learning and about using new learning techniques. We also want to help teachers create a classroom environment that is non-threatening, encourages peer review, and allows students to grow more knowledgeable. We want them to have a strong desire to learn because of their experiences in the classroom.
How Does Project-based Learning Differ from a Traditional Classroom Environment?

In a traditional classroom students are encouraged to listen and learn instead of ask questions, but inquiry is the way we learn!

Memorizing facts and information isn’t the way to learn but it is prevalent in a traditional classroom. Facts change and information can be found if research techniques are learned. It is more important to know how to process information than to know the actual facts.

The style of the classroom also changes in an inquiry-based classroom. No longer is the classroom environment governed by short isolated lessons, but is ruled by interconnected lessons that help students develop skills necessary for inquiry, then allow them to utilize those skills in problem solving. Inquiry based learning can be integrated into classes from all subjects.

<table>
<thead>
<tr>
<th>Traditional Classroom</th>
<th>Project-based Classroom</th>
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<tbody>
<tr>
<td><strong>Regarding the Curriculum</strong></td>
<td></td>
</tr>
<tr>
<td>Fixed curriculum</td>
<td>Long-term, interdisciplinary, student-centered projects on real world issues of interest to the student team</td>
</tr>
<tr>
<td>Broad area of instruction</td>
<td>Has depth of investigation and research</td>
</tr>
<tr>
<td>Rote memorization of facts</td>
<td>Understand processes, encourages critical thinking skills and discovery</td>
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</tbody>
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| **Regarding the Classroom** | |
| Teaching for the Industrial Age where the classroom reflects this through rows of seats neatly placed | Teaching for the Technology Age where the classroom has flexible seating, students collaborating in teams |
| Attempt to keep everyone together, learning at the same pace | Customized instruction, many different levels and topics |
| Individual efforts to accomplish a goal | Encourages working in heterogeneous teams to accomplish the goal |

| **Regarding the Teacher** | |
| Teacher as the lecturer and director of instruction, the “expert” | Teacher as facilitator and resource person. |

| **Regarding the Student** | |
| Dependent upon the teacher, carrying out instructions | Take responsibility for self, define their own tasks and work as a member of a team for large blocks of time with a goal, with the teacher as a guide |
| Goal is to perform well on standardized tests | Goal is to become a life-long learner |

| **Regarding the Use of Technology** | |
| Reward for finishing a task or a punishment for not mastering a concept | Integrated tool used in all aspects of the classroom, such as problem solving, communication, analyzing results, and information gathering. |
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**Inquiry-based learning activities**

Inquiry-based learning shifts from short, isolated, teacher lessons to learning activities that:

- Are long-term - such as a project that continues through the term.
- Are interdisciplinary - involving all areas of educational development for the student. For example, studying the scientific phenomena, writing the mathematical model, analysis of the results, writing a technical description of the project development process.
- Are student-centered – Students become responsible for the completion of their own work, encouraging their fellow team members to stay on task.
- Are integrated with real world issues and practices – Students develop projects about real world phenomena

Inquiry based activities:

- Improve education for all students – Students have a different attitude about their learning process. They no longer feel the need to ask “When are we ever going to use this?”
- Transform teaching – The role of the teacher changes from instructor to facilitator.
- Provide opportunities for students to pursue their own interest
- Allow students to make decisions – Given the requirements of the development of a computational science project, students are able to decide upon a topic, decide upon a team and the role of each team member, and are able to manage the project development phase with the assistance and supervision of the teacher
- Facilitate student integration of content
- Teach students to use their minds, apply what they learn, be technologically literate, have skills and self-confidence

**Teacher activities**

In an Inquiry based classroom, teachers:

- Become the coach, a facilitator in the background. The teacher teaches the class the content that everyone needs to learn, then supervises the project development phase and continues to teach on a need to know basis.
- Learn with the students.
- Show students that they should expect bumps, mistakes -- wrong turns. When students encounter wrong turns or wrong answers, they are encouraged to try again and try to understand why they came to the incorrect answer.
- Help teams develop
- Encourage mentoring on the part of teacher/teacher, teacher/student, and student/student.

In an Inquiry based classroom, teachers experience:

- More coaching and modeling, less telling.
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- Finding out with their students - less knowing for certain; less being the expert.
- More cross-disciplinary thinking, less specialization.
- More teamwork, less privacy and isolation.
- More multi-dimensional assessment, less paper and pencil testing.
- More varied materials and media.

**Student Responses**

In an Inquiry based classroom, students move
- From following orders to carrying out self-directed learning activities.
- From memorizing and repeating to discovering, integrating, and presenting.
- From listening and reacting to communicating and taking responsibility
- From knowledge of facts, terms, and content to understanding processes.
- From theory to application of theory.
- From teacher dependent to empowered.
- From learning in youth to lifelong learning.

**Assessment in a Project-based Classroom**

In an inquiry-based classroom, assessment
- Moves from repeating information to measuring understanding.
- Presentations to others, includes peer review by classmates.
- Includes portfolios, journals, and daily work.
- Measures a student’s ability to work as a member of a team.
- Is often accomplished through the use of rubrics.
- Measures completion of short term as well as long term goals.
- Includes self-assessment.
- Does not always measure a right or wrong answer but the student’s ability to solve a problem.
- Takes into account individual learning styles.
- May take into account different student backgrounds.
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Classroom Environment in a Project-Based Classroom

Introduction

A project based classroom is a SMART Classroom

- S tudents being successful
- M otivation – intrinsic and powerful
- A utonomy – independent learning
- R eflective – thinking centered classroom
- T eachers – teaching with technology

Problem-based Classroom Activities

Prompt:
Begin with a prompt by the teacher about the topic of discussion, the attention-getter. The teacher throws out bait in the form of a topic for discussion.

Brainstorm:
Students brainstorm about ideas to discuss and extensions to the prompt.

Discovery:
Teams of students investigate the phenomena discussed, perhaps several parts of it. They may even pose a scientific research question and a method of solving it.

Communication:
Teams return to the group with their findings.

A computational science class goes one step further – student initiation.
Teacher Role and Benefits in a Project-based classroom

Teacher’s Role

Teachers have a very unique role in the project-based classroom, they are no longer the expert, the all-knowing, but they are the channel through which the students acquire the skills for learning.

A project-based classroom environment allows the teacher to become involved in student learning, not as a supplier of knowledge but as a prod for students to gain that knowledge on his or her own. And, on a personal basis, it helps us get out of our rut, helps us to enjoy teaching again.

Teachers can make a huge difference in the intellectual maturity of their students. This is an age where classrooms are equipped with bigger and better equipment, technology opportunities that did not exist only a few years ago, and software that is touted to make our job easier, but without the experience to use the available equipment and technology by the teacher. We must learn that technology is only a tool enabling teachers and students to become more proficient in knowledge acquisition. Project-based learning is a means of accomplishing this goal.

This is not an easy task for teachers, and not an undertaking for the faint of heart, but it is an exciting opportunity.

It is not only teachers who have the responsibility to change the way students gain knowledge. But teachers do have a huge responsibility because they are the first point of contact with their students and have a tremendous influence over the way they learn.

All of us have a stake in creating a learning environment for students that will enrich their learning experiences, make them enthusiastic learners, and motivate them to pursue excellence in scholastic achievement.

Teacher Benefits

Rewarding Professional Experience

Teachers have said that a project-based classroom changes their attitude about teaching and is professionally rewarding in several ways:

- Students are more motivated and enthusiastic about learning.
- Teachers often experience revitalization about teaching and a renewed interest in expanding their own knowledge through additional studies, either on their own or by taking additional classes.
- Teachers acquire new professional skills in technology.
- Teachers gain professional support from their administration, their peers, and the academic community.
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- Teachers gain software, technical and technology skills that enable them to expand their content area. Teachers also learn mathematical modeling, a national standard focus.
- Teachers learn effective and rewarding teaching techniques.
- Teachers work collaboratively with other teachers to develop interdisciplinary problems or projects, often distant collaborations.
- Teachers employ a variety of assessment methods.
- Teachers learn to manage a class where student teams are working independently and at a different pace.
- Teachers lead students to take more responsibility by guiding rather than directing.  

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Allen, Dick; Corones, Jim; Gentry, Edna; Helland, Barb; Summers, Barbara; Zachmann, Dave; Pardee, William, Editor and Facilitator; “Potential Benefits of an Ideal AiS Program”, 1999.
Student Benefits in a Project-based Classroom

**Intellectual Maturity**
As students become more accustomed to learning in a problem-based environment they gain a level of intellectual maturity not readily seen in a traditional classroom.

Through involvement in a problem-based classroom environment students gain:

- **Self Confidence** – Students gain self-confidence by resolving a problem through a self-directed study of the problem and its solution.
- **Desire to Achieve** – Students begin to realize the connections between academic study and the world around them. They discover they have more potential to achieve than the realized. They become enthusiastic about the content and the solution of their problem. Students begin to answer their own “When am I ever going to use this?” questions.
- **Analytical Skills** – Students develop analytical skills such as critical thinking skills, problem defining and problem solving skills. They begin to analyze real-world problems and think of questions on their own that need to be answered. They begin to think critically about a problem and its possible solutions. These critical thinking skills are necessary to be a productive lifelong learner and contributor to society. Students develop skills to solve problems that they would normally consider too hard for a traditional classroom. These skills may include research techniques, data analysis, working as a member of a team, graphing, technical writing, presenting to their peers, and peer review. All of these skills may necessary for future career opportunities.
- **Teamwork abilities** - Students learn set short-term and long-term goals, how to set deadlines and meet them, how to make work assignments, and organizational skills. Through working in a team students learn to be responsible to others.

**Ability to Use Technology to Solve Problems**
Students learn to use available and emerging technology that will benefit them in their professional choices. They develop more than just technical skills, they learn:
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- To use computers to solve realistic problems. This ability is very powerful for students because it uncovers potential that they may not have realized they possess.
- Valuable research skills. In Alabama, students learn to use the Alabama Virtual Library in addition to other important research tools that can be found online.
- To use appropriate problem solving software, such as modeling and graphing software.
- Communication skills that will enable them to present their work to their peers.\(^4\)

**How do I ensure that students are on task?**

The atmosphere in a project-based classroom differs from that in a traditional classroom. No longer are students sitting passively in rows – all working at the same pace and level and doing exactly the same assignment. In the project-based classroom some students will be working on research, others discussing strategy for solving their problem, still others working with modeling, or analysis. Although major benchmarks with established deadlines will be set, students will be in various stages throughout the problem solving process.

This is often a transition that presents challenges to the teacher, especially if he/she has only taught in a traditional classroom setting. It may even seem that the class is “out of control”. These challenges can quickly lead to frustration on the part of the teacher if not solved. Teachers must realize this is the nature of the project-based classroom and the real concern is not order but ensuring that students are on task. This can be accomplished by the teacher always being aware of what the students are doing. Some suggestion:

1) The teacher should require each team to maintain a journal (electronic journals are easy for both student and teacher to access). By examining the journals, the teacher will know where the students are in their problem solving process and be better able to guide them to the next step. Strategic questioning makes the student think and make the necessary decisions to move forward.

2) The teacher should be an ex-officio member of each team, working closely with the team;

3) Teams should set an agenda for themselves, identifying activities that must be carried out by each team member. The agenda should be detailed in the team journal and submitted to the teacher;

4) Teams should regularly recap the latest activities, noting items accomplished and items that still need to be done. The recap should be maintained in the team journal and submitted to the teacher;

5) During regular workdays, the teacher should monitor the various projects by actively moving about the room, randomly inquiring project progress from each team.

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\(^4\) Allen, Dick; Corones, Jim; Gentry, Edna; Helland, Barb; Summers, Barbara; Zachmann, Dave; Pardee, William, Editor and Facilitator; “Potential Benefits of an Ideal AiS Program”, 1999.
6) The teacher and team members should realize that it is possible for a team to work the entire class period without completing a task. The team members should not continue to be “stumped” without alerting the teacher and asking for help.

**Assessment in a Project Based Classroom**

Traditional assessment techniques are not always appropriate in an Inquiry Based classroom. In an environment where students are encouraged to articulate questions of interest to them and “take the plunge” for discovery, assessment techniques should be planned that will support this type of learning. Also, we are teaching students how to think critically and analyze findings. Assessing their ability to think critically cannot be done effectively in traditional multiple-choice or true-false assessment instruments. Instead, we want to assess whether or not they can apply what they have learned to their everyday life.

Assessment procedures and techniques in a project-based classroom differ from traditional methods because you are measuring different activities. You want to assess how well students work in a team, whether or not they have selected and refined their project topic, if they are able to perform advanced research, if they have developed a reasonable mathematical and computational model to describe their problem if they have written their technical description correctly, and if they present their project findings effectively. These are activities that cannot be measured in traditional ways.

Suggested assessment techniques:

- Portfolio of completed assignments – physical documentation of student work, such as sample programs written, spreadsheet models, visualization samples, portions of the technical paper, etc.
- Journal containing reflections, summaries of articles, notes, etc.;
- Peer review – Peer Review should be a non-threatening activity. It should never make the students hesitant to present but instead should be a setting where the other students can offer suggestions and ask questions that may enhance the project;
- Use of a scoring rubric;
- Team self evaluations;
- Evaluation of team members by team members – Evaluation of team members by team members could be done using a boss-employee scenario. Have each person pretend to be the boss of the team who must pay each team member, including him/herself. The boss should take a specific amount of money and divide it according to the amount of work done by the team members and justify the amount of money given to each;
- Teacher observation and monitoring;
- Periodic presentations as project updates – Periodic presentations as project updates could occur regularly where student teams give an update on their project. Peer reviews could be done at this time;
• Written report sections – Written report sections could be graded. A timeline should be distributed at the beginning of the year so that students will be able to plan ahead for deadlines;
• Skills test – teacher would give to each student (or possibly teams) instructions on a job to complete (perhaps a program to write, an excel activity, a visualization problem, a writing assignment, etc.) and a certain amount of time to complete it. This may be announced or unannounced;
• Tests or quizzes;
• Final technical paper;
• Final project presentation;
• Final project display;
• Scoring rubrics – an effective way to score such documents as the student technical paper.

Finally, assessment in a project-based classroom should be:
• Flexible to meet the varying needs, levels, and backgrounds of the students
• Fair, reasonable, and equitable
• Forthcoming and accommodating
• Focused on the process rather than the topic.

Inquiry-Based Learning Meets the Science, Mathematics, and Technology Standards

Summary of National Science, Mathematics, and Technology Education Standards that are met by a project-based classroom.

Abilities Necessary to do Scientific Inquiry
• Identify questions and concepts that guide scientific investigations;
• Design and conduct scientific investigation;
• Use technology and mathematics to improve investigations and communications;
• Formulate and revise scientific explanations and models using logic and evidence;
• Recognize and analyze alternative explanations and models;
• Communicate and defend a scientific argument;
• Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them;
• Select and use appropriate statistical methods to analyze data;
• Develop and evaluate inferences and predictions that are based on data;

Understandings about problem solving:
• Scientists usually inquire about how physical, living, or designed systems function;
• Scientists conduct investigations for a wide variety of reasons;
• Scientists rely on technology to enhance the gathering and manipulation of data;
• Mathematics is essential in scientific inquiry;
Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modifications; and it must be based on historical and current scientific knowledge;

Results of scientific inquiry—new knowledge and new methods—emerge from different types of investigations and public communications among scientists.

Students should be able to build new mathematical knowledge through problem solving;

Students should be able to solve problems that arise in mathematics and in other contexts;

Students should be able to apply and adapt a variety of appropriate strategies to solve problems;

Students should be able to monitor and reflect on the process of mathematical problem solving.

Students should be able to use the language of mathematics to express mathematical ideas precisely.

Students should be able to recognize and use connections among mathematical ideas;

Students should be able to understand how mathematical ideas interconnect and build on one another to produce a coherent whole;

Students should be able to recognize and apply mathematics in contexts outside of mathematics.

Students should be able to use representations to model and interpret physical, social, and mathematical phenomena.

Teachers create developmentally appropriate learning opportunities that apply technology-enhanced instructional strategies to support the diverse needs of learners.

Teachers implement curriculum plans, that include methods and strategies for applying technology to maximize student learning.
Template for Use in an Inquiry-Based Classroom

Module Description

A brief description (abstract) of the module, including the content area, the problem being addressed, the modeling technique, and a conclusion.

Requirements

The requirements would include prerequisites, software and hardware requirements, and any materials or Internet sites required to complete the module.

Objectives

The objectives or goals of the module are what you expect your students to accomplish through the completion of the module. The objectives should be written in such a way that they can be measured. The objectives and the assessment techniques are closely tied together.

Introduction

This includes any background information necessary for completion of the module. It should also contain references to online sites where content information can be found. The introduction should set the stage for the rest of the module, including the rationale for completing the module.

Featured Facts

This section has more specific background information. It should include specific background knowledge that a student should possess before proceeding though the module. Mathematical and scientific theory and principles should be included in this section. A listing of variables for the mathematical model with an explanation of the variables should be included in this section.

Activities and Procedures

This section provides a procedural list of instructions for completing the module. If appropriate include a timeline for the activities.

References and Resources

List all sources of contributing materials.

Teaching Strategies

List hints and tips that will help other teachers who wish to use your module. Provide methods that were used in the module and how they worked. Suggestions and additional teaching strategies could also be provided by teachers who use the module.

Thought Provoking Questions

Questions that could be asked of students to provoke them to logical thinking. These questions should lead the students to formulate questions of their own. Include the answers to the questions.
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Standards Addressed
Include any national science and mathematics standards addressed by the module.

Cross Curricular Connections
Specify ways that other curriculum areas can be included in the teaching of the module. Try to identify methods for addressing the four core subjects of mathematics, science, language arts, and social science.

Assessment Techniques
List innovative and appropriate methods for assessing student completion of the module. In addition to traditional methods of assessment, other methods must be incorporated into the module, such as journals, notebooks, presentations, displays, etc. Assessment strategies should measure the objectives stated in the module.

Glossary
A listing of module specific terms.