I've come to the frightening conclusion that I am the decisive element in the classroom. It is my personal approach that creates the climate. It is my daily mood that makes the weather. As a teacher I possess a tremendous power to make a child's life miserable or joyous. I can be a tool of torture or an instrument of inspiration.

Haim Ginott

Learning Cycle as an Instructional Theory

I. Introduction.

The Learning Cycle is an instructional theory, based on a constructivist learning theory, for teachers to facilitating students' learning. Students and teachers are actively involved. The students relate past experiences to their present experience and construct knowledge to generate greater understanding through their explorations and communication with their class mates. The teacher is actively involved in the creation of tasks and implementation of instructional strategies to facilitate students' learning, as well as the teacher's learning about the students' abilities and the variety of ways students understand concepts and communicate. The Learning Cycle is a very flexible instructional process based on a constructivist learning theory that maximizes students' learning and teacher's learning about students.

II. The Theory.

The Learning Cycle was originated by Robert Karplus in the Science Curriculum Improvement Study (SCIS) This approach has a widespread applicability and has been used as an instructional process in mathematics, language arts, and social studies texts as well as science. The Learning Cycle includes three stages: exploration, invention, and discovery.

In the ***exploration stage***, the students explore materials or ideas. This exploration presents conditions that will encourage students to use accurate concepts or misconceptions they have previously conceptualized. As students explore they connect their past understanding to their current explorations. Piaget called this assimilation. As the student interprets the present event with their current understanding they may experience a discrepancy between their past experiences and the information they are currently exploring. Piaget called this disequilibration. This state of confusion, disequilibration, motivates the student to manipulate the materials and/or ideas to create a new schema, accommodation, for understanding and returning the student to a state of equilibration. What the student learns, or the concept conceptualized by the student, may be classified in a number of ways: as generative knowledge (subject matter knowledge), process knowledge, an attitude about the subject; the person them self; another person; society; or a culture, a concept related to the perspective of the subject, or any combination of these.

In the ***invention stage***, the teacher begins by inviting the student to share data they have collected. As students share their exploration experiences, they communicate their personal interpretations of their exploration. This communication can be presented in a variety of ways (oral, written in words or visual representation, acted out, sung, or any combination) for each concept. The use of the term, invention stage, is another way of stating that the students are inventing a concept and through the sharing of their collective explorations they will refine their understandings by trying to connect their experiences and understandings with other persons' experiences and understandings. The teacher asks probing questions to facilitate this exchange of information and introduces vocabulary as necessary.

Students are encouraged by the teacher to organize the data and to invent methods for expressing concluding statements or a visualization. The author defines visualizations as a picture, diagram chart, or graph that enables the learner to explain their interpretation of their exploration. The process of communicating the student's cognitive ideas are crucial at this particular stage. The student must be able to recognize an interpretation for the data examined, to organize a logical presentation of evidence that lends itself to be understood by others, and to communicate in both a positive social and affective setting information about a particular area and the processes in creating that information.

In the ***discovery stage***, the teacher and / or students implement an activity to extend or apply the concept. The student begins to put the idea that has been invented to use. The student may do this by extending the understanding of the concept by exploring its limits or joining it with other related concepts to make a more complex concept (generalization). The discovery phase is the last phase of the Learning Cycle; however, it is also the first phase of the Learning Cycle. It is in this phase that the next exploration phase is initiated and many times will be recognized as exploration.

Using the Learning Cycle as an instructional process requires the educator to be cognizant of the interplay between the instructional process, a learning theory, and the students' conceptualization of concepts.

Assessment

The author asserts that the assessment process used in the Learning Cycle is an on-going process used by the teacher and student to check what students know and how well they know it. The initial check of what students know (diagnosis) and how well they know it is done during the exploration. It is at this time that the teacher and students may want to adjust the exploration task for the entire class or for individual students depending on the information from the teacher's probing. They should be alert to assess concepts and not isolated pieces of information that alone do not suggest understanding of relationships of facts and/or concepts. Assessment continues during the exploration and invention with assessment at the conclusion of invention for generalization. While the format of all assessment is

to ask questions or pose problems to challenge the students' observations and reasoning, the questions or problems poised at the end of the invention allow students to extend or generalize with the newly conceptualized concept. This gives students an opportunity to use the concept in new ways to solve a problem or answer a question and the teacher the opportunity to see how well the students can generalize the concept. This assessment is different than a discovery activity in that the questions or problems are short in duration and the quality of the answers is based on the use of the concept invented in a logical way more than the answer's accuracy. However, this assessment may many times lead into or be used to create the discovery activity.

Assessment includes information from these quick check assessments during invention as well as other information created by the students throughout their experiences and the more traditional kinds of tests given to students periodically. While the intent of this section is not to present information on general kinds of assessment some thoughts on assessment related to the learning cycle follow:

(1) Assessment information can be collected from student created records of events, procedures, or random thoughts. It is imperative that the classroom teacher examine these records on a regular basis. Young children can draw their observations. As they learn to write, they can label and then write the descriptions of what they have done. As their ability to read and write matures, they can be given written questions to focus their attention on information they will need to know. These written questions would be used to assess student's understanding of the concepts.

(2) Information can be collected on what students know about how and what to record from their observations. This can be inferred from products of their work or recorded on video tape as students work to solve problems.

(3) Information can be collected on how students use concepts recently learned to solve problems they have not experienced. Teachers must develop appropriate tasks where students can learn and apply processes in a systematic manner in their everyday activities. As students work on these everyday tasks information on how they solve problems can be collected to assess student growth.

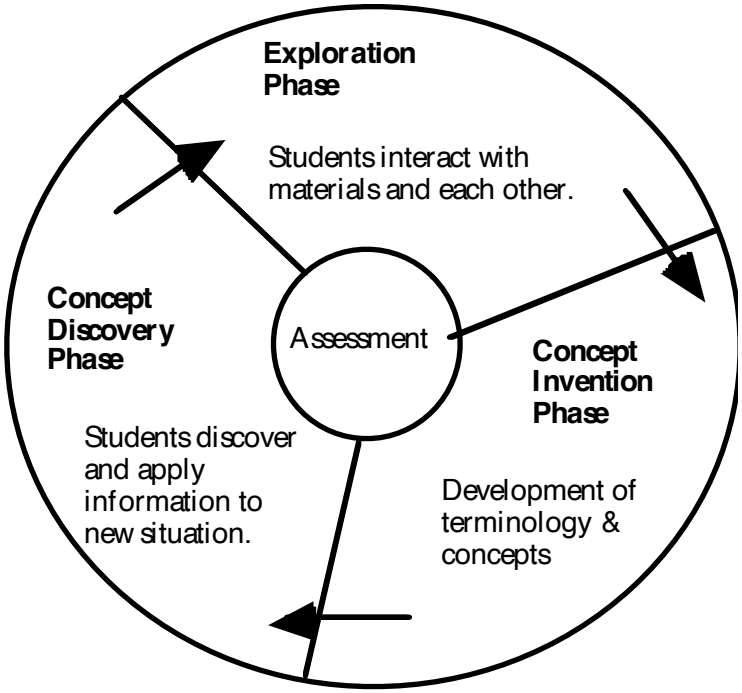
(4) Information can be collected from more than cognitive knowledge level questions. (e.g., How many centimeters in a meter? More appropriate questions would be similar to the following. (a) You measured the room with your feet. The class agreed on a standard straw as a unit of measurement. Why did you choose to use feet? (b) Would green bean seeds be a good choice for a standard unit? Why? or Why not?)

(5) Information collected should be comprehensive. Information can include a variety of categories (knowledge, process, affective, perspective, personal, and social).

(6) Information collected can be longitudinal to have a reference for student progress, both individual and group.

(7) Information collected can be related to criteria and norm references.

The Model



adapted from Barman

III. The Development of a Planning Framework

If the learner is going to construct scientifically accurate concepts, they must be involved in an exploration of information that will support the concept. This is achieved in the exploration stage. The Learning Cycle is an instructional process that facilitates learning by providing opportunities to the student to explore by beginning with their personal ideas rather than someone else's idea that they may not be ready to accept. The teacher helps organize experiences that will encourage students to push their personal ideas to discover their limitations. As they do so they will discover the quality of their ideas. Sometimes making minor adjustments and other times discarding their ideas and replacing them with better.

For teachers to create this kind of learning experience it is important for them to understand the concepts students are to learn, the information required to conceptualize the concepts, and activities that can be explored that make this information available for students understanding. For teachers to provide students with meaningful experiences they must have a certain amount of information available to them. This information and its organization will be referred to as an

organizational framework. Outstanding teachers have an organizational framework in mind if not on paper. To help teacher-educators plan and facilitate learning the author has created an organizational framework. This framework has as its major areas: Concepts for students to conceptualize, supporting information for the concepts, possible student misconceptions, assessment, activities, materials, and procedures. A description of each area of the framework, a framework outline, and a completed framework, or lesson plan, follows.

Concepts. The major ideas to be conceptualized by the students over a period of time. The teacher must (1) know what concepts that are developmentally appropriate for students to learn, and (2) formulate a concise statement for each concept explored. The teacher should remember that concepts are the ideas about a particular phenomenon students construct from a learning experience. A concept, then, is what the students will have in their heads when they walk out of the classroom.

Concepts can be classified in a number of areas. These areas are identified in national and state standards through the learned societies and need to be selected by communities as part of the school curriculum. Some possible categories are included for a frame of reference. The reader is encouraged to explore different classification systems to meet their students' needs.

Possible Concept Categories:

- **Generative Knowledge.** The concepts that are information created in the topic area that include the areas subject knowledge.
- **Process.** The knowledge needed to collect data, organize data, and create information in a topic area.
- **Dispositions.** The attitudes people have who desire to use the topic area for a particular purpose.
- **Perspective.** The understanding of how a topic area developed and how it has been, is, or could be used by society.
- **Personal.** The understanding of ones abilities for self-improvement.
- **Social.** The understanding of how to interact with people for the good of the person and group.

Supporting Information. The concepts or facts needed to invent or conceptualize a concept.

Misconceptions. Ideas that people have that don't coincide accurately with the intended concept. Students' developmental abilities should be taken into account when determining accuracy.

Activity. What the students will do to move toward the development of the concept. Activities should provide students experiences where the supporting

information is available so students may conceptualize the concept during their exploration.

Assessment. What probing questions or problems can be asked or given to assess the students progress toward conceptualization and generalization of the concept.

Materials. The supplies needed to do the activities.

Discovery. When students gain additional information or knowledge about a concept, apply the concept, or use it in a different situation. The discovery activity many times is the beginning of another exploration and invention activity.

Learning Cycle Framework

Title of Activity:		**Grade Level:**	
Concept Assessment Information			
Concepts	**Supporting Inforr**	**Misconceptio**	**Assessment:**
	1.		

Procedure for Concept Conceptualization and Generalizatio
Activity Overview/ Objective: 1.
Materials:
Exploration Procedure
Invention Procedure
Discovery Activity

IV. Sample Lesson

A narrative of a sample lesson on electricity and a planning framework follows. The lesson is an introductory electricity lesson for upper elementary students.

Exploration. The teacher may choose two paths for exploration. One closed and another open. In the first, the teacher has selected a concept and task with the intention that students will conceptualize the concept by doing the task and discussing the results. In the second, the teacher asks the students what they are interested in learning. The teacher and students plan their learning based on their needs or desires. The teacher works with the students posing questions or helps the students pose questions. Next, they plan a task to explore. Imagine a classroom where the teacher/students have decided to investigate electricity. The teacher explains to the students that one way to begin to learn about a topic is to take the smallest unit or system of the topic and learn as much about that system as possible. The teacher and students decide that the smallest system for electricity would be one light bulb, one battery, and one wire. The teacher provides each student with the one light bulb, one wire, and one battery and challenges them to find-out as much as they can about the system.

Students begin to collect data and make observations such as: the battery has a top and a bottom, the top has a bump and the bottom has an indent, the wire has a plastic coating, it has a metal inside (copper wire), the bulb has threads on the side, a bump (terminal) on the bottom, a glass top, filament inside, etc. They also learn operational information. If a wire is run from the bottom of a battery to a light bulb, it will not light. The same is true if a wire is run from the top of the battery to the bulb. The bulb will light if the bottom touches the top of the battery and a wire runs from the side of the bulb to the bottom of the battery. As students explore, they can be encouraged to draw pictures that show the bulb lit; as well as, pictures that show the bulb not lit. After students light the bulb, they are challenged to light the bulb with the same objects in different ways. If students are unable to light the bulb and appear to be frustrated, the teacher can have them explain the strategies they have tried. At this point, teacher assistance is critical; helping the student to direct attention to a different strategy sustains student interest to continue exploration. After a reasonable amount of time: when student interest is decreasing students have collect two or three ways to light the bulb, or have collected all four ways to light the bulb it is time to move to the next step.

Invention. Invention is initiated with a discussion of the data collected from the exploration. Students share information to gain a deeper understanding of the bulb, wire, and battery system. This allows them to assimilate and accommodate information from their exploration and communicate what they understand. This is facilitated with drawings, diagrams, oral communications, and any other communication aid. Invention focuses students on ways to understand as they discuss, write, organize, classify, consolidate, analyze, verify, and communicate their understanding of the concept and related information in meaningful ways. It also allows the teacher to assess the level of students' understanding of what has occurred. This discussion allows the students' to conceptualize the concept of a closed circuit, compare it to each others, and through minimal teacher intervention examine the reasoning behind their concept of a closed circuit and how the scientific process is used to increase their understanding

of not only this simple circuit but how they might generalize what they learned about this circuit to more complicated circuits.

Even if students have conceptualized a scientifically acceptable concept of a closed circuit during the exploration stage, the invention stage is still necessary to complete their learning experience. The invention stage allows students to operationalize a procedure for lighting the bulb and communicating it in a scientific manner appropriate to the students' developmental level and predict how it might be applied in other situations all of which makes the learning experience more meaningful. A finished communication for middle schools students might be similar to the following statements. To have a transfer of energy with a battery, wire, and flashlight bulb there must be a continuous path (a closed circuit) with the following parts of the objects in the path: 1) top of the battery; 2) bottom of the battery; 3) threaded side of the bulb; and 4) bottom of the bulb such that the electricity can flow through each object. A diagram of four possible, different models of this system could be drawn with all four places marked in color and the path of electricity traced. Further, students would use this model to predict how other circuits may or may not be closed.

Discovery. The lesson might very well end here, but the cycle should continue with the discovery of how the concept can be used. This could be done through any number of activities pre-selected by the teacher, or selected from ideas the students generate during the invention stage, or at the beginning of the discovery stage. The main consideration is students discover a use for their new concept of a closed circuit and extensions of it.

Some sample activities: Use the closed circuit to create a circuit tester and use it to test objects by putting them into the circuit and recording if the circuit is "open" or "closed" for each object. The students would use the concept of a closed circuit not only when they make the circuit tester but each time they test each object. The teacher can observe students during the activity and use it as assessment. As the students use the concept of closed circuit to classify objects, they are discovering the utility and power of the concept and collecting data to conceptualize new concepts, conductor and non-conductor. Therefore, this activity is discovery for how to apply the concept and is the beginning of a new Learning Cycle exploration and invention for the concepts of conductor and non-conductor. The activity could also be used as a discovery for the application of the concept of a model by having students create a model to explain the difference between a conductor and non-conductor.

Another activity would have students explore by giving them an additional bulb, or battery. Have the students draw ten different circuits, predict if each would be opened or closed, theorize why, experiment for each, and record all results. This gives students opportunities to generalize the concept of a closed circuit to more complex circuits and leads to other possible inventions: parallel or series circuits for sources, receivers, or in combination.

Both examples show a usefulness for expanding the concept of a closed circuit and begin another cycle with an exploration stage. Students' progress through these cycles is similar to the construction of knowledge according to Piaget's learning theory and a progression of increasing knowledge through scientific investigation.

During the exploration phase, the teacher is continually assessing to see what the students know and how well they know it. Based on this information the teacher must decide if the students are able to proceed without becoming frustrated or bored. If the teacher determines this is not possible, then the teacher must intervene. During the invention phase, all of the activity is centered around assessment of what students know and how well they know it. This begins by sharing the students' data. The data can be discussed and evaluated according to how it was collected, how it was organized, the reasoning used to gain meaning, and how all of this is communicated orally, visually, and written. During this discussion the teacher gains valuable information of what students know and how well they know it. Based on this information the teacher must decide what to say or what NOT to say to facilitate student learning. As the students use the learning cycle, the teacher will discover not only what students know and how well they know it but how students in general understand concepts, articulate concepts, and generalize concepts to refine them or create new ones. Therefore, assessment information is authentic and performance based.

V. Summary and Conclusion

The learning cycle is a process for teachers to organize and analyze learning experiences. While teachers may use the learning cycle in an inquiry or discovery type lesson outstanding teachers teach students how to engage in learning experiences on their own. To achieve this goal concepts must be conceptualized in a variety of categories: subject areas, processes, disposition toward subject areas, perspective of subject areas, personal power to enable learning, and social power to cooperate with others. A student that is lacking in any category will not have received the best possible education. A teacher's responsibility is to help students achieve in all areas and the learning cycle can be a tool to help teachers do this.

Learning Cycle Framework for Electricity Closed Circuit

Title of Activity: Closed circuit		**Age Level:** 11 up	
		Concept Assessment Information	
Knowledge Conc	**Supporting Informatio**	**Misconceptions**	**Assessment**
A closed circuit is created with continuous path through the: (1) top battery, (2) bottom of the battery, (3) the bulb, and (4) threaded side of the Closed circuit transfers electri (Generalization)	Battery has electricity Top has metal bump Bottom has metal plate Wire has plastic coating Metal (copper) inside the wire Light bulb has a metal tip on the bott Light bulb has metal threads on the si Light bulb has glass on the top Light bulb has a filament inside Light bulb lights Electricity passes through the l	1. Light bulbs and batteries have no i 2. Energy flows from the battery to th bulb like water from a hose. 3. There must be a circle for the energ	Exploration 1. Ask how to light the bulb. 2. Cruise and ask how to change c positions to find different circui Invention 1. Ask what they found. 2. Ask for all possible ways. 3. Ask how energy is transferred. Review Ask why alternative concept 2 and 3 create a closed circuit. Generalization Ask how they could use their model continuous closed path and fou connections to transfer electric motor.
Process Concep	**Supporting Inform**	**Student Views**	**Assessment**
Models are representations of a real s can be used to explain and predict ho interact.	1. Pictures or symbols represent obje 2. A symbol represents an energy sou receiver. 3. Energy transfer is represented by a path. 4. The continuous path must enter an both the receiver and source. 5. The pattern described or illustrated model can be transformed in part and changed in other parts. 6. Essential parts of the system are tw on the battery and two terminals on th	Each circuit is unique and there are n elements among different circuits. Models are like pictures. Systems can not be understood.	Exploration Ask to draw or write explanatio circuits Invention Ask to draw or write explanatio circuits Generalization Use the model to predict if othe will or will not transfer energy.

Disposition Concept	Supporting Inform	Student Views	Assessment
Curiosity and persistence are needed and understand problems.	1. The bulb will light. 2. How the bulb lights makes sense, f pattern, and is consistent. 3. Varying the positions of the objects an interaction. 4. A method of lighting the bulb can b through experimentation. 5. Information about lighting this bul interesting. 6. The scientific method can be used information. 7. Observations can provide data. 8. Problems can be solved with logic.	1. There are not enough objects in the light the bulb.	Exploration 1. What strategies do you know? 2. How can you use them? 3. Have you tried ... Invention 1. What strategies did you use? 2. How else might the strategies b 3. What would you try to discover
Perspective Conce	**Supporting Informati**	**Student View**	**Assessment**
Scientific inquiry requires verifiable testable hypotheses and logical reaso search for unbiased theories.	1. Can think of a way of lighting the l and observe if it works. 2. There may be more than one way t bulb. 3. Several ways can be tested. 4. A pattern may be used to generate ways. 5. Other people may suggest differen light the bulb that can be tested and c with an experiment.	Some people are smart and just know work. People get their ideas from books.	Exploration Can you light the bulb? Invention Could we add bulbs and batterie same Generalization What other systems could we ch the same procedure thing?
Personal Concep			
I am capable of learning and s problems.	1. If I just try some ideas I can figure to light the bulb. 2. If one way doesn't work I can try a 3. I found one way I might be able to another. 4. I can make all the circuits that wer in class. 5. I can understand how the transfer c could happen from a source to a recei	I am not smart enough to unde to solve problems.	Exploration Can you light the bulb Invention Do you want to create more mo how other electric circuits work
Social Concept			
Sharing ideas helps everyone l	1. Other people have ideas that I have thought of. 2. When I listen to people who agree think it helps me to be more confiden know. 3. The more we talk about something understand it. 4. The more we talk about something can explain what I know to others. 5. I presume other people can be help same way I am.	I know everything and don't need to others. other peoples' ideas are dumb.	Invention How do you feel about the discu the circuits? Generalization How might you use what you le today?

Concept Conceptualization Activity Information
Activity Overview: 1. All students will construct closed circuits with a light bulb, battery, and wire; draw a model to explain the transfer of ene battery system; explain how the wire, bulb, battery system works; and how a model can be used to explain and predict (Cognitive synthesis, Affective responding, Psychomotor guided response)
Materials: Light bulb, battery, and wire for each student. Motors for assessment
Exploration Procedure

1. Give one wire, battery, and light bulb to each student
2. Challenge them to light the bulb.
3. Encourage them to find more ways to light the bulb.
4. If students can not light the bulb have them explain the strategy they are using and try to get them to abandon the strateg
5. Encourage students to draw diagrams of their circuits.

Invention Procedure

1. Have students draw circuits on the board.
2. Have students label the circuits which lit the bulb and circuits which did not light the bulb.
3. Have them find similarities for the circuits that lit the bulb.
4. Have them write an operational definition for the circuit. (A closed circuit for a flashlight bulb, battery continuous path (closed circuit) with the following parts in the path: (1) top of the battery, (2) bottom bulb, and (4) threaded side of the bulb.)
5. Have students write their discoveries in their learning logs.
6. Ask why alternative concept 2 and 3 do not create a closed circuit.
7. Ask how they could use their model of a continuous closed path and four connections to transfer elect
8. What strategies did you use?
9. How else might the strategies be used?
10. Use the model to predict if other circuits will or will not transfer energy Could we add bulbs and batte
11. How do you feel about the discussion of the circuits?
12. Do you want to create more models for how other electric circuits work?

Discovery Activity

1. Have students make circuits with more objects.
2. Have students make a closed circuit for a circuit tester and test objects to see if they close the circuit (co conductor).

Classroom Indicators for the Learning Cycle

Exploration

Positive

Teacher:

1. Focuses students attention
   a) Uses manipulatives
      (1) "Move the red block over by the yellow block."
      (2) "What would the design look like if you rotated that block 90 degrees?"
   b) Asks questions
      (1) "What do you think of Marie's ideas?"
      (2) "What would happen if you tried five?"
   c) Makes statements
      (1) "Try the same problem with dinosaurs."
      (2) "Turn the battery upside down."
      (3) "Show me what you have done."
      (4) "Explain what you are doing."
      (5) "Talk to me."
2. Monitors students' progress
   a) Cruises the room (actively moves about the room looking for "the action").
   b) Listens to students
3. Facilitates students learning
   (a) Encourages student manipulation of materials
      (1) "Mary use these."
      (2) "Can you show me with the bears?"
   (b) Encourages student communication about the manipulation of materials, discussion of concepts, problems, processes, or models
      (1) "Alex, show Jan how you worked your problem."
      (2) "Kim, use Chris's dinosaurs and solve your problem."
      (3) "The turtle group share your solution with the tiger group".
   (c) Asks questions to focus student learning
      (1) "What did you do?"
      (2) "Why did you move the red cube here?"
      (3) "Why did you do that?"
      (4) "What do you know?"
      (5) "What would you like to know?"
   (d) Ask questions to facilitate the students collection of data
      (1) "How many are in the circle?"
      (2) "How many more do you have than Chris?"
   (e) Ask questions to encourage higher order thinking skills
      (1) "How is the way you worked the problem different than the way Kim did?"
      (2) "Which way do you like best?"
   (f) Use wait-time (three to five seconds) and halt time (10 + seconds).
      (1) "Deedra, what do you think?"

Student:

1. Manipulates objects
2. Records data
   a) Mental memories
   b) Pictures
   c) Number sentences
   d) Equations
   e) Diagrams
   f) Maps
3. Asks questions
   a) "What if I do this?"
   b) "Can we try this?"
4. Makes predictions

a) “I think it will be the same if we use shells.”
b) “I think it will be the same no matter what we use.”

5. Tests predictions
6. Generates alternatives
   a) “Five grouped with three is the same as four grouped with four.”
7. Open-minded
   a) “Lets try it.”
   b) “I don’t think so but try it.”

Neutral
Teacher:

1. Motivational statements
   a) “Today we are going to play the cave game.”
   b) “You can do this.”
2. Directions
   a) “Each group should have five red squares and three bears.”
   b) “I want the red group over at the circular table.”
   c) “Put three bears in the red circle and two bears in the yellow circle.”
3. Initial demonstrations on how to manipulate, NOT how to get answer.

Student:

1. Questions
   a) “What do we do?”
   b) “Like this?”
   c) “Should we ...”
2. Statements that have neither a positive or negative effect
   a) “It’s green.”
   b) “Chris has the purple cow.”

Negative
Teacher:

1. Tells students the “correct answer”
   a) “No, the answer is five.”
2. Explains the concept
   a) “You move this group over here and that’s addition.”
   b) “When you take this part from this group you subtract.”
3. Tells the concept
   a) “Today we are going to see what addition is.”
   b) “You add all the problems on page 70 and subtract all the problems on page 71.”
4. Tells the conclusion
   a) “You should see that the amount in both containers is the same volume.”
   b) “You should all have the minute hand back at the 12.”
5. Introduces the concept with numerals, number statements, equations, or algorithms
   a) “Everyone write the number four.”
   b) “Put a plus sign beside the three.”
6. Solves the problem
   a) “Three take away two is one.”
   b) “Five times five is twenty-five.”
7. Insists on one answer or only one method for solving problems “You have to put the big number on the top.”
   a) “You can’t subtract five from three.”
8. Tells students to do their own work
   a) “Kim keep your eyes on your own paper.”
   b) “Chris keep your hands to your self.”
9. Tells student they are wrong
   a) “No, your answer is wrong.”
   b) “What’s the matter with you we just did these before recess.”
10. Leads students step by step
    a) “Put the four here, then put the three below it, and draw a line,now use your touch points to count from three to seven, and write the seven below the line.”

Student:

1. Tells answers

a) “Pssst! Lin, the answer is five.”
b) “Move that over there and you have it.”

2. Does not manipulate objects
3. Manipulates objects without direction
4. Sits and watches the teacher do problems
5. Work individually with little student interaction
6. Stop after one solution

INVENT

Positive
Teacher:

1. Has students share data with a group
   a) “What data did you collect?”
   b) “How did you do the problem?”
   c) “What evidence do you have?”
2. Has students organize group or groups data
   a) “All the students that have five stand in line here.”
   b) “Everyone write their data on the board.”
3. Has students draw pictures, diagrams, charts, graphs to share their data with a group or to organize group data
   a) “Group one, draw your picture on the board.”
   b) “Jo, walk around with your picture so all can see it.”
4. Teacher provides vocabulary for concepts or processes
   a) “A word to describe what we have learned is ...” (Writes the word on the overhead)
5. Teacher has a student or group of students demonstrate what they discovered during their exploration
   a) “Maria, use the rods to show what you mean.”
   b) “Alex’s group, show us what you did.”
6. Actively solicites and uses students’ ideas
   a) “Jan says that...”
   b) “Use Brent’s idea, then Marty’s, and go from there.”
7. Relates concepts, processes, and models to students’ experiences “How many of you go to the store?”
   a) “How can you use these ideas to make change?”
8. Seeks alternative solutions and explanations from students
   a) “Who can do it another way?”
   b) “Mark thought of this way. Will it work?”
9. Encourages students to express attitudes
   a) “What do you think?”
   b) “Which way do you like best?”
10. Monitors the discussion
11. Uses wait-time and halt-time
12. Has students express themselves in their own words
13. Has students use concepts, vocabulary, processes or algorithms in different situations
   a) “Shana say that again only use the word that we have on the board.”
   b) “Who can use the words on the board to describe what we have done today.”
14. Extends the concept
   a) “What other problems can we solve the same way?”
   b) “How else can we use this idea?”
15. Make predictions
16. Make and use models

Student

1. Explain the data they have collected from the exploration
   a) “We took four cows and put them here and then took two dogs and ....
2. Ask questions about data
   a) “How did you get four?”
   b) “Why did you do that?”
3. Express attitudes

a) “I like the way Tina’s group did theirs.”
b) “Yes!”

4. Use a process
5. Offer suggestions
   a) “Why don’t you ...”
6. Use newly invented vocabulary to describe the exploration, invention, or possible application.
7. Demonstrate how they obtained data
8. Demonstrate process or algorithm
9. Extend the concept

Neutral
Teacher:

1. Behavioral interventions
2. Classroom management

Student:

1. Use their learning or their group’s learning and set goals

Negative
Teacher:

1. Accepts explanation without reason
2. Accepts explanation without relating it to student collected data
3. Has no concept in mind
4. Does not ask student for explanations
5. Introduces unrelated concepts or skills
6. Does not listen to alternative strategies
7. Provides definitive answers and talks for prolonged periods of time.
8. Leads student step by step to a solution
9. Explains how to work the problem
10. Provides an algorithm or memorized answer
11. Quiz or tests only for algorithm, vocabulary, and/or facts
12. Students do not use new vocabulary or state concepts, process, or models in their own words.

Student:

1. Memorize facts, vocabulary, or algorithm without understanding

Discovery

Positive
Teacher:

1. Creates learning environments that will allow the student to:
2. Explore with the invented concept, process, or model in a different setting or situation
3. Solve different problems with the invented process, or model
4. Use the concept, process, or model to increase its complexity
5. Use the concept, process, or model to generate new concepts, processes, or models.

Student:

1. Explores with a previously invented concept, process, or model in a different setting or situation
2. Solves different problems using a previously invented process, or model
3. Uses a previously invented concept, process, or model and increases its complexity
4. Use a previously invented concept, process, or model and generates new concepts, processes, or models.

Neutral
Teacher:

1. Reviews the previous days concepts, processes, or model
2. Tests the previous days concepts, processes, or model

Negative
Teacher:

1. Does not refer or build on the previous days work
2. Moves on to another unrelated topic in which the vocabulary, concepts, processes, or model can not likely be used or have an effect
3. Moves to another topic in which using the previous days vocabulary, concept, process, or model would have a negative effect if the students tried to transfer it

Student

1. Do not use the vocabulary, concept, process, or model outside of school or in school

Probability (die) Framework

Title of Activity: Probability of a one-sided die		**Age Level: 4+**	
Concept Assessment Information			
Concepts	**Supporting Inform**	**Student's Views**	**Assessment**
A fair die has equal probabilit each side.	• A die has six sides. • The numbers on a die are • Each number appears onl • Each side has an equal ch being rolled. (The die is f Each side same size...	• I can cause a certain num rolled (blowing, throw ha throw a certain way...). • It is magic.	• Have students predict the probability for a die with different amount of sides • Use a spinner with equal partitions and predict the probability for each secti selected.

Concept Conceptualization Activity Information
Activity Overview (Bloom's Taxonomy 1. Knowledge**, 2.** Comprehension**, 3.** Application**, 4. An** Evaluation**)** Students roll two dice at least 36 times, collect the sums, and draw a conclusion a
Materials Die, pencil, paper
Exploration Procedure
1. Ask students how to display date. If students do not know how to arrange data have them graph the number of rolls for e 2. Students put their data on the board. 3. Analyze the data. 4. Have students communicate the concept. 5. Assess
Invention Procedure
1. Tell the students they will roll two dice 36 times, record the numbers and the sums for each roll. 2. Students roll the dice and collect the data.
Discovery Activity
Find the probability for sums of two six sided dice.

Probability (dice) Learning Cycle Framework

Title of Activity: Probability for two six-sided die	**Age Level: 5+**

Concept Assessment Information

Concepts	Supporting Information	Student's Views	Assessment
The probability of an outcome is the specific outcomes out of the total nur possible outcomes of one event.	• Each die has six sides. • Each die is the same. • Each side has an equal chance c rolled. • Each die is fair. • The sums of the die are: 2, 3, 4, 9, 110, 11, 12. • There is one way for the dice to sum of 2, two for 3...six for 7 fi For a total of 36.	• I can cause a certain number to (blowing, throw hard, throw a c way...). • It is magic.	• Have students predict the proba certain sums if dice with a diffe amount of sides than six were r summed. • Use a spinner with unequal part predict the probability for each be selected.

Concept Conceptualization Activity Information

Activity Overview (Bloom's Taxonomy 1. Knowledge**, 2.** Comprehension**, 3.** Application**, 4. Analysis, 5. Synthesis, 6.** Eval

Students roll two dice at least 36 times, collect the sums, and draw a conclusion a

Materials Die, pencil, paper

Exploration Procedure

1. Tell the students they will roll two dice 36 times, record the numbers and the sums for each roll.
2. Students roll the dice and collect the data.

Invention Procedure

1. Ask students how to display data. If students do not know how to arrange data have them graph the number of rolls for e **axis**). Data could also include the addends for each sum.
2. Students put their data on the board.
3. Analyze the data by having students. It may be necessary to list every pair of addends for each sum 2-12.
4. Have students communicate the concept and support its accuracy with the data.
5. Assess

Discovery Activity

Have students create an investigation of their own.

Probability (Tiles in Sock) Learning Cycle Mathematics Planning Framework

Title of Activity: Probability for Tiles in a Sock		**Grade Level: 2+**	
Concept Assessment Information			
Concepts	**Supporting Information**	**Student's Views**	**Assessment**
The probability of an outcome is the specific outcomes out of the total nur possible outcomes of one event.	• Each sock has three tiles. • Each tile is the same size. • A tile must be one of three colo • Each tile has an equal chance o drawn. • The possible combinations are: color, two the same color and o different, three different colors. • The more objects of one color, t the chance of that color being s • The more trials, the more accur theoretical values that are obtai	• I can cause a certain tile to be s (think real hard, pick a certain v • One tile always gets chosen. • It is magic.	• Have students predict the proba selection of tiles with different combinations. • Use a spinner with equal partiti different colors and have the stu predict the probability for each section to be selected.
Accurace of predition may be increas more trials.	• Each selection increases the pos selecting all tiles at least once. • Predictions are derived from po • Some possibilities have a better occuring than others. • Some possibilities are not likely • Some possibilities are impossib happen.	• Young students do not understa proportion . They might look at individual data and see that the are closer to the actual numbers sum of all the class numbers an how it is more accurate.	• Have students predict the proba selection of tiles with different combinations. • Use a spinner with equal partiti different colors and have the stu predict the probability for each section to be selected.

Concept Conceptualization Activity Information
Activity Overview (Bloom's Taxonomy 1. Knowledge**, 2.** Comprehension**, 3.** Application**, 4. Analysis, 5. Synthesis, 6.** Evaluation**)** Students will make a specific number of random selections with replacement and draw a conclusion about the tile p
Materials for each group Sock, three colored tiles, graphing supplies pencil, paper and a chalkboard for the entire class
Exploration Procedure
1. Ask students if they think they can predict exactly what the population of tiles in a sock is without dumping all of the objects. Ask if they would lik 2. Show the socks and explain that each sock has identical colored tiles. 3. Tell the students that they will predict the color of each tile for the sock population. 4. Divide the class into groups of three. 5. Outline the following directions on the board. Each student will rotate the following roles: selector, counter, recorder. Selector: Draws the tile from the sock, announces its color, returns the tile to the sock, and shakes the sock. Counter: Keeps track of the number of trials the selector has taken. Recorder: Records the color of each tile on the group paper. Selector: Returns the tile to the sock. Each person selects a tile four (4) times. Each group thinks about, discusses the results and then writes a group prediction. 6. Ask someone to repeat the instructions 7. Students complete the task. 8. Cruise the room and observe interactions, note critical comments, answer questions about procedures, and make sure groups record the necessary inf

Invention Procedure
1. Ask students how to display data. If students do not know how to arrange data have them record the number of each color selected on a chart with the group's name on the side and the number of times a certain color was drawn in the cells. 2. Students put their data on the chart and explain how they arrived at their predictions. 3. Have the students decide that more draws would help to obtain a more accurate prediction.
Exploration Procedure
1. Have students repeat the process with four draws. 2. Remind them about the directions on the board. 3. Check for understanding. 4. Students complete the task. 5. Cruise the room and observe interactions, note critical comments, answer questions about procedures, and make sure groups record the necessary in
Invention Procedure
1. Ask students how to display data. If students do not know how to arrange data have them record the number of each color selected on a chart with the group's name on the side and the number of times a certain color was drawn in the cells. 2. Students put their data on the chart and explain how they arrived at their predictions 3. Ask student what would happen if all the classes data was put on one chart. 4. Create a class chart by having all students place a colored polka-dot or sticky-notes for each colored tile on a graph. 5. Have the students explain the graph. 6. Have students predict the probability for selection of tiles with different combinations. 7. Use a spinner with equal partitions of different colors and have the students predict the probability for each colored section to be selected.
Discovery Activity
Have students create an investigation of their own.