

# Using Problem-Based Learning Activities to Teach Mathematics

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# What is PBL?

“Problem-based learning (PBL) is an instructional method in which students learn through facilitated problem solving.” (p. 235)

Hmelo-Silver, C.E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, 16(3), 235-266

# Four Basic Components

- ❖ Creating situations or scenarios
- ❖ Posing problems
- ❖ Solving problems
- ❖ Applying mathematics

Xia, X., Lu, C., Wang, B., Song, Y. (2007). Experimental research on mathematics teaching of “situated creation and problem-based instruction” in Chinese primary and secondary schools. *Front. Educ. China*, 2(3), 366-377.



# How Does PBL Differ from Other Pedagogies?

# Subject-Based Learning

**START**

Given problem to  
illustrate how to use it

Students told what  
they need to know

Learn it  
(?)

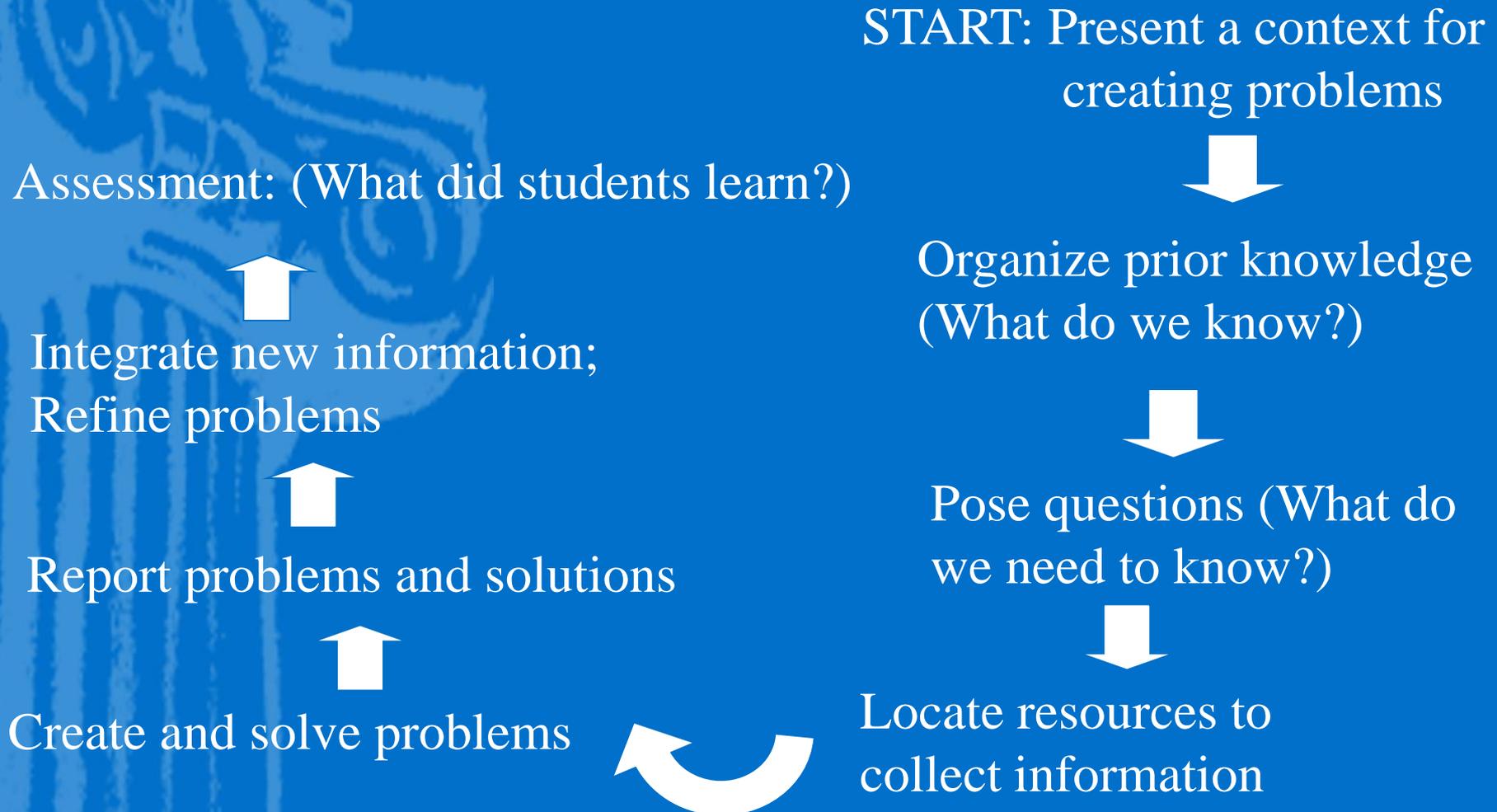
*Adapted from Smith et al, 2005.*

# Problem-Based Learning—The Problem Comes First!



*From Smith et al, 2005.*

# PBL: Our Process



*Adapted from Smith et al, 2005.*

# Types of Learning Objectives

## **Content-oriented:** subject specific

- ❖ Basic knowledge and understanding of specific concepts, skills, & generalizations in the discipline

## **Process-oriented:** global skills

- ❖ Effective communication: oral and written
- ❖ Acquiring and evaluating information
- ❖ Working effectively with others
- ❖ Higher order, critical thinking

# Goals of PBL\*

help students develop

- ❖ Flexible knowledge: knowledge that can be applied
- ❖ Effective problem-solving skills
- ❖ Self-directed learning skills – metacognitive strategies
- ❖ Effective collaboration skills
- ❖ Intrinsic motivation – motivated by own interests

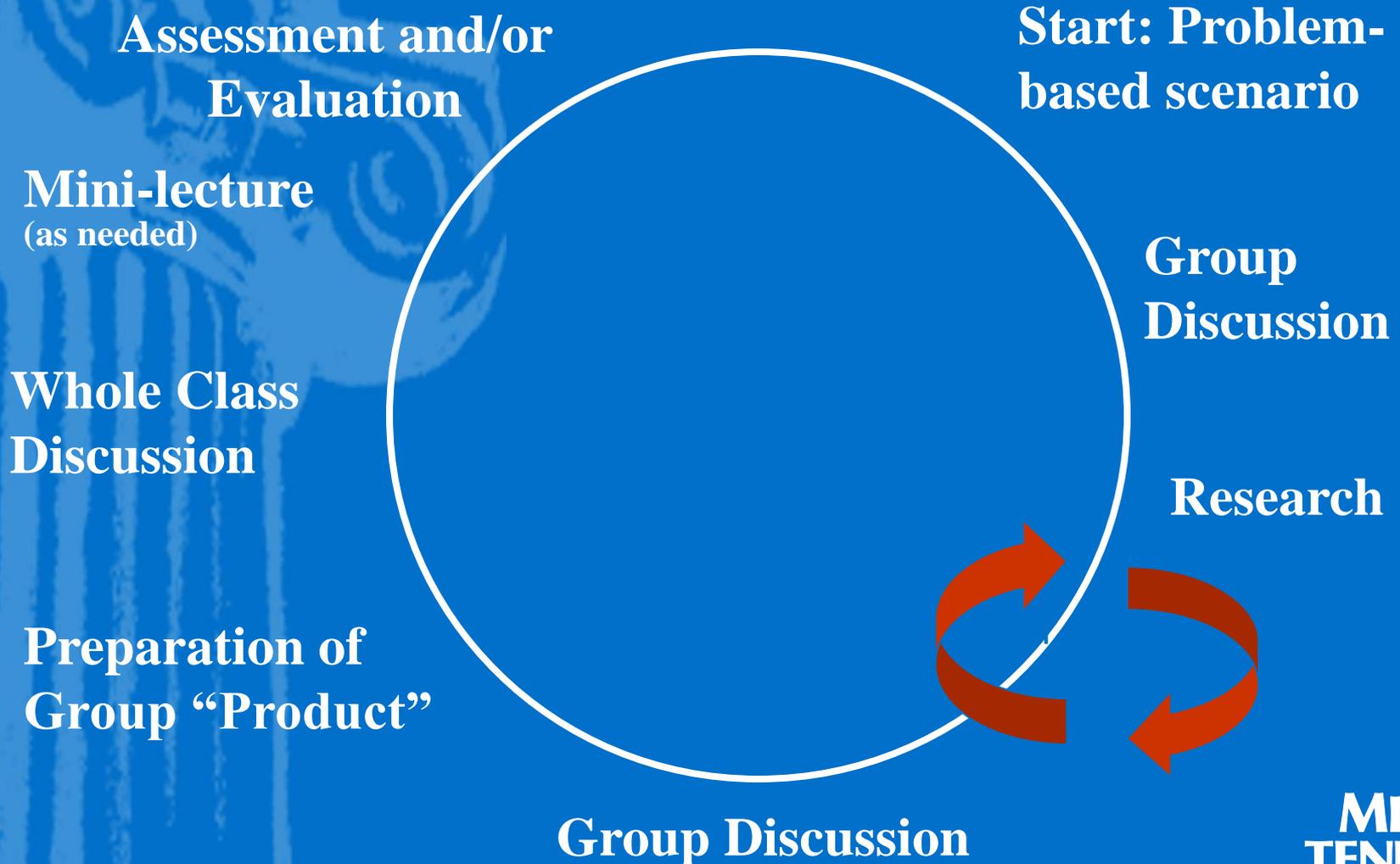
\*Hmelo-Silver, C.E. (2004). *Educ. Psych. Rev.* 16, 235-266.

# “Hybrid” PBL

Non-exclusive use of problem-driven learning in a class—integrated with other pedagogies

May include separate lecture segments or other active-learning components

# Problem-Based Learning – Hybrid Model



# Pay My Bills PBL Scenario

TBR students started the 2011-2012 academic year with a 6.1% increase in tuition over the 2010-2011 academic year

(<http://www.murfreesboropost.com/mtsu-tuition-to-climb-again-cms-17748>) . Based upon the current economy, forecasts about the country's economic recovery are grim. Parents and students can anticipate a continuation of tuition increases over the next five years.

# Instructor Created Problems

Tuition at MTSU for the 2010-2011 school year was \$6,298 and the TBR announced a 6.1% increase in tuition for 2011-2012. There are 26,442 students enrolled at MTSU. How much extra money will the increase in tuition generate? The SGA comes up with an idea to prevent the increase in tuition and still bring in the additional revenue for MTSU. They suggest that every student participate in a fund raiser. The Widgets will cost \$5 a dozen. The Widget maker will keep 22.5% of all the sales and the university will get the rest of the proceeds. How many Widgets will need to be sold so that students do not have to pay a higher tuition than last year? How many Widgets will each student need to sell? Is that a reasonable amount of Widgets to expect every student to sell?

# Instructor Created Problems

Rod normally drives around Murfreesboro for fun and social interaction. His truck gets 15mpg while driving in town. In August, Rod learned of the increase in tuition. He decided to stop driving around town to save gas and thus save money. He will put this saved money toward the increase in tuition. If Rod's normal loop around town is 4.1 miles and he drives this loop 3 times a night, then how long will he have to quit driving around town (use \$3.30 per gallon as the price for gas)? In other words, when will Rod save enough money to pay the extra tuition?

# Instructor Created Problems

A student at a certain university receives an e-mail announcing that she has a balance on her account. The balance is an even 3-digit integer such that the ratio of the balance and the next even integer higher than the balance is the non-terminating repeating decimal  $0.99777\dots$ . How much does the student owe?

# Other Scenarios: Paws for a Cause

One hundred twenty-one dogs were rescued from a Warren County puppy mill in March 2011 by the Animal Rescue Corps (ARC). They were temporarily sheltered at the Nashville Fairgrounds until a court hearing was held to determine if the dogs should be returned to the owner or become wards of the ARC and put up for adoption. The dogs were held at the Fairgrounds facility for nine days. The ARC asked volunteers to donate food, water, crates, beds, bowls, towels, money, and time to care for the dogs until the court date. The owner was charged ten dollars per dog per day for the care and services received at the Fairgrounds.

# Other Scenarios: Home for the Holidays

Is that a pumpkin spice latte in your hand? Have you gained five pounds from eating all of your leftover Halloween candy? That's right, fall is here and Thanksgiving is right around the corner. You are so excited that you decide to host your family's Thanksgiving dinner. This is your first time to host Thanksgiving dinner and you want everything to go smoothly so you have decided to start planning your Thanksgiving dinner now. Your attention to detail will be the key to your successful Thanksgiving dinner.

# Research Design

Comparative analyses were completed between students in a number concepts course taught using a lecture approach (control group) and students in a number concepts course taught using PBL experiences and problem solving (experimental group).

# Data Collected

- ❖ Arithmetic Proficiency Test (APT): Pre-test
- ❖ Researcher Designed Content Knowledge Test: Pre-test and Post-test
- ❖ Mathematics Anxiety Rating Scale (MARS): Pre-test and Post-test
- ❖ Attitudes Toward Mathematics Inventory (ATMI): Pre-test and Post-test

# Research Question 1

Will university students preparing to become elementary school teachers learn basic mathematics concepts, skills, and generalizations better by participating in a student centered learning environment utilizing PBL experiences and problem solving versus a traditional lecture methodology?

# Research Question 2

Will university students preparing to become elementary school teachers decrease their mathematics anxiety by participating in a student centered learning environment utilizing PBL experiences and problem solving versus a traditional lecture methodology?

# Research Question 3

Will university students preparing to become elementary school teachers improve their attitudes toward mathematics by participating in a student centered learning environment utilizing PBL experiences and problem solving versus a traditional lecture methodology?

# Analysis & Results

- ❖ t-tests were used to determine if there were significant differences between the two groups on content knowledge, mathematics anxiety, attitudes toward mathematics, and a post-test problem solving assessment.
- ❖ There were no significant differences in both content knowledge and mathematics anxiety between the two groups.
- ❖ Neither group experienced a significant change in their mathematics anxiety.

# Analysis & Results

- ❖ The students who experienced PBL and problem solving had a significant decrease in their attitudes towards mathematics from pre-test to post-test.
- ❖ The students who experienced PBL and problem solving were better problem solvers than the control group.

# What the Researchers Learned (anecdotal)

- ❖ Compared to traditional instruction PBL requires more effort and time in preparation.
- ❖ It is difficult to get students to buy into the PBL process as a way to learn mathematics.
- ❖ More direct instruction should have been used on some concepts and skills with the experimental group.
- ❖ PBL and problem solving are more efficient at covering concepts.
- ❖ Students learning through collaborative group PBL experiences learned how to communicate their thoughts, solution paths, and reasoning.

# Implementation Difficulties (anecdotal)

- ❖ Maturity of the students
- ❖ Students' ability to work collaboratively
- ❖ Class size
- ❖ One semester is not enough time
- ❖ Arithmetic skills and calculator use
- ❖ Student presentations of solution methods
- ❖ Problem creation is difficult for many students in the beginning

# Question to be Answered

- ❖ Students can construct knowledge through PBL and problem solving but how does the construction of knowledge occur?

# References

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