Welcome.
How Does Prior Knowledge Affect Learning?

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Objectives of this workshop

You will be able to:

• Identify four problematic prior knowledge (PK) situations.
• Generate examples of each in your own discipline.
• Discuss instructional strategies to address each situation.
• Enlist students’ PK more effectively to promote learning.
Concept map

You were asked (as homework) to create a concept map that addresses the question:

How does students’ prior knowledge affect their learning?

What were some of the issues and connections you identified?
Themes and big ideas?
Students ≠ blank slates

• They come into our classrooms with facts, models, attitudes, beliefs, and assumptions.
• They build on and interpret incoming information through the lens of their existing knowledge.

“The most important single factor influencing learning is what the learner already knows.”

D.P. Ausubel (1968)
Prior knowledge plays a critical role in new learning...

but can be problematic if it’s...

• Inactive
• Insufficient
• Inappropriate
• Inaccurate
LEARNING PRINCIPLE: Students’ prior knowledge can help or hinder learning.

Inactive Prior Knowledge
Try this logic problem

Each card below has a letter on one side and a number on the other. Rule: If a card has a vowel on one side, it must have an even number on the other side.

What is the minimum number of cards you would have to turn over to check whether the rule is being followed? Which ones? (adapted from Wason, 1966, 1968)
Try this logic problem

Each card below has a letter on one side and a number on the other. Rule: If a card has a vowel on one side, it must have an even number on the other side.

Correct answer

A 2 X 3

What is the minimum number of cards you would have to turn over to check whether the rule is being followed? Which ones? (adapted from Wason, 1966, 1968)
Now try it using prior knowledge

Each card represents a student at a bar. The age of the student is on one side and what he’s drinking is on the other. Rule: If a person is drinking a beer, then he is over 21.

What is the minimum number of cards you would have to turn over to check whether everyone’s behavior is legal? Which ones? (adapted from Griggs and Cox, 1982)
Students are better able to reason if they can draw on prior knowledge.
Which is great, but...

Students do not necessarily think to use the relevant prior knowledge they possess.
Students were given this scenario and solution

**Scenario:**
A general wishes to capture a fortress. Roads radiate outward from the fortress, but all of them have been mined so that if a large force travels on them, it will detonate the mines. A full-scale direct attack is therefore impossible.

**Solution:**
Divide the army into small groups, send each group to the fortress on a different road, and have the groups converge simultaneously on the fortress.

(adapted from Gick and Holyoak, 1980)
But they did not think to apply the same reasoning to this analogous problem.

Scenario:
A patient has a malignant, inoperable tumor. If the tumor is not destroyed, the patient will die. Fortunately, there is a kind of ray that can be used to destroy the tumor. If the ray reaches the tumor at sufficiently high intensity, the tumor will be destroyed. However, if the ray is used at high intensity, it will damage surrounding tissues.

Question:
What type of procedure might be used to destroy the tumor with the rays, and at the same time avoid destroying healthy tissue?

(adapted from Gick and Holyoak, 1980)
Can you think of situations in your own teaching when students possessed relevant prior knowledge but didn’t use it?

Why do you think they didn’t?
Because students do not necessarily tap into relevant prior knowledge...

It’s important to deliberately *activate* PK to facilitate learning and performance.
Martin and Pressly, 1991

• Asked Canadian adults to study facts about Canadian history (e.g., The first game of baseball was played in Ontario).
• Found that subjects did not learn or retain most of the information.
• However, when researchers posed “why” questions (e.g., “Why would Ontario have been the first place baseball was played?”):
  o Participants drew on their knowledge of Canadian history.
  o Related it logically to the new information.
  o Learned more new information.
  o Retained it longer.
Garfield, Del Mas, & Chance, 2007

• Designed a study in a college statistics course, focusing on the concept of variability.

• Asked students to:
  o generate examples of activities in their own lives with high or low variability
  o represent their examples graphically
  o draw on these examples as they reasoned about aspects of variability.

• Found students who generated relevant prior knowledge outperformed students in a traditionally-taught class 2 to 1.
Strategies Brainstorm

Drawing on these examples and your own experiences, what are some ways we can activate students’ prior knowledge to promote learning?

What can you do in a place like CMU-Q when you simply don’t know much about students’ background knowledge and experiences?

Quickly jot some ideas down.
A few strategies

Begin each class with a reminder of (or questions about) ideas and terminology from the previous class.

Connect material to students’ lives and interests (requires finding out what these are!)

Ask questions that require students to remember and connect to relevant knowledge (from your own course or previous courses).

Use reminders and prompts (“Remember the sorting algorithm we used in the last assignment?”)

(See handout for more)
Insufficient Prior Knowledge
Students may lack critical background knowledge and skills. This undermines subsequent learning, e.g...

<table>
<thead>
<tr>
<th>If students don’t know...</th>
<th>...they can’t effectively...</th>
</tr>
</thead>
<tbody>
<tr>
<td>colonial history</td>
<td>analyze contemporary geopolitics</td>
</tr>
<tr>
<td>differential equations</td>
<td>solve complex engineering problems</td>
</tr>
<tr>
<td>principles of visual hierarchy</td>
<td>create typographical designs</td>
</tr>
</tbody>
</table>

What’s an example from your field?
Thus, it’s important for instructors to know what students do and don’t know, in order to...

- Fill gaps
- Reinforce weak areas
- Build on a strong foundation

and avoid this →
However, four things make assessing students’ prior knowledge tricky...
(1) Faculty may have difficulty identifying prerequisite prior knowledge.

To figure out whether students know what they need to know coming into a course or assignment, faculty need to be able to break down complex tasks into component knowledge and skills.

This can be difficult for experts, who tend to roll these skills together and take them for granted.
(2) Students may not assess their own abilities accurately.

- They often over-estimate their skills and knowledge (Kruger and Dunning, 1999). This is especially true of weaker students!

- Thus, asking your students “Do you know X?” may yield unreliable information.
(3) Students may have prior knowledge, but not of the right type or level.

Knowing *what* ≠ knowing *why*
Knowing *how* ≠ knowing *when*

Just because students have one kind of knowledge does not mean they have another.
So, for example, students might be able to...

• define Newton’s Second Law, but not apply it.

• create a typographical design but not explain their design decisions.

• describe different statistical tests, but not identify which to apply in the context of a problem.

• apply a formula, but not explain the concept from which it is derived.
(4) Students may have the necessary prior knowledge but still lack *fluency*. They may “know” it, but not well enough to use it efficiently, smoothly, or in combination with other skills.

*Example:* Students have learned Java but are not yet comfortable enough with it to use it efficiently when solving computer science problems.
Again, four things make assessing students’ prior knowledge tricky:

1. Faculty may have difficulty identifying prerequisite prior knowledge.
2. Students may not assess their own abilities accurately.
3. Students may have prior knowledge, but not of the right type/level.
4. Students may have the necessary prior knowledge, but lack fluency.
Given these complexities, how can faculty determine...

• what prior knowledge students should have?
• whether students possess it?
• how to address gaps?
Strategy to identify prerequisite knowledge and skills: **task analysis**

Think of a task you’ve assigned and ask yourself: “What will students need to know to do this well?”

Keep asking that question for each of the sub-skills, drilling down until you feel confident that students are on a firm foundation.
Strategy to reveal students’ prior knowledge: prior knowledge assessments

Short assessments of students’ knowledge coming into a course or unit. Can be either a performance assessment or a self-assessment.

For example...
Sample performance assessment

Which of the following best describes the process of mitosis?

☐ Within a cell, chromosomes create copies of themselves and then separate into identical sets, forming two new cells.

☐ Within a cell chromosome pairs divide, one half of each pair forming a new cell.

☐ Within a pair of chromosomes, a piece breaks off and attaches to the other end or middle, thus creating a new gene.
Sample self-assessment 1

How familiar are you with Karnaugh maps?

☐ I have never heard of them or I have heard of them but don’t know what they are.
☐ I have some idea what they are, but don’t know when or how to use them.
☐ I have a clear idea what they are but haven’t used them.
☐ I can explain what they are, what they do, and I have used them.
Sample self-assessment 2

For each of the following Shakespearean plays, place a check mark in the cell if it describes your experience.

<table>
<thead>
<tr>
<th>Play</th>
<th>Have read it</th>
<th>Have seen a live performance</th>
<th>Have seen a TV or movie production</th>
<th>Have written a college-level paper on it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamlet</td>
<td></td>
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<tr>
<td>King Lear</td>
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<tr>
<td>Henry IV</td>
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<tr>
<td>Othello</td>
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</tbody>
</table>
Some strategies to address gaps in students’ prior knowledge

<table>
<thead>
<tr>
<th>Small number of students with insufficient PK</th>
<th>Direct students to remedial resources.</th>
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<tbody>
<tr>
<td></td>
<td>Provide additional review sessions.</td>
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<tr>
<td>Large number of students with insufficient PK</td>
<td>Bite the bullet and teach the skills and knowledge students need.</td>
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<tr>
<td></td>
<td>Reevaluate the curriculum.</td>
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<td></td>
<td>Offer supplementary pre-college or summer courses.</td>
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</table>
What doesn’t work?

• plowing forward when large numbers of students are missing critical prior knowledge.

• expecting students to make up significant missing knowledge on their own time (e.g., through lengthy help sessions).
Inappropriate Prior Knowledge
From Fish is Fish
by Leo Leonni
Knowledge may be appropriate for one context and inappropriate for another. If students apply prior knowledge that is inappropriate for a new learning context, it can:

- impede learning
- distort understanding
- inhibit performance
Students may, for example:

Misapply **disciplinary conventions**.
- E.g., apply expressive writing conventions to lab reports.

Act on inappropriate **cultural assumptions**.
- E.g., Refrain from asking questions so as not to insult the teacher.

Confuse technical with **non-technical meanings**.
- E.g., Interpret “negative reinforcement” as punishment.

Carry **analogies** too far.
- E.g., Over-analogize from skeletal muscles to heart muscles.
Can you think of any situations in your own teaching when students have...

- Applied inappropriate disciplinary conventions?
- Acted on inappropriate cultural assumptions?
- Confused technical with non-technical meanings?
- Carried an analogy too far?

...or otherwise misapplied prior knowledge?
Strategies Brainstorm

In small groups, identify 2-4 things instructors can do to help students avoid applying prior knowledge inappropriately.
A few strategies...

Explicitly identify discipline-specific conventions.

Explicitly identify cultural expectations.

Highlight differences between everyday and technical meanings.

(More strategies in handout)
Inaccurate prior knowledge
Some of the things we think we know are just plain wrong.

Inaccurate prior knowledge can distort new learning.

“It’s not what we don’t know that gives us trouble. It’s what we know that ain’t so.”

Will Rogers
Some inaccuracies can be corrected simply by introducing accurate knowledge, others not.

Particularly tenacious inaccuracies are referred to as “misconceptions”.
Why are misconceptions so tenacious?

- reinforced over time and across contexts
- may include accurate—as well as inaccurate—elements
- may permit some successful explanations and predictions

(think of stereotypes)
Can you think of any common student misconceptions in your discipline?
Strategies Brainstorm

What strategies can we use to help correct inaccurate student knowledge?
Strategy: Bridging Analogies

Clement (1993):

- College students could not comprehend how a table exerts force on a book placed on its surface.
- Clement used “bridging analogies” to help students grasp the concept:

  ![Diagram of Anchor, Bridging Case, Target]

- Intermediate cases helped bridge the conceptual divide.
LEARNING PRINCIPLE: Students’ prior knowledge can help or hinder learning.

Implications: As instructors, we need to:

1. Find out what students know and don’t know.
2. Activate relevant prior knowledge.
3. Identify and fill gaps in students’ knowledge.
4. Identify inappropriate applications of prior knowledge.
5. Actively work to correct misconceptions.
Questions? Thoughts?
Bibliography


Thank you.