Differentiated Instruction Techniques

Supporting documentation from the presentation

Dana Center Mathematics PATHWAYS

Concept Checks

- What are they?
    - A combination of the formative assessment strategy of Voting Questions and the think-pair-share protocol
    - A quick way to identify student familiarity with, understanding of, and misconceptions about a chosen concept.
    - Can be used at the beginning, middle, or end of instruction of a concept
    - Students vote on what they think is the correct answer to a multiple-choice question and practice making coherent, clear, and precise arguments to support their position.

- What makes them low-floor, high-ceiling?
    - Low floor: All students can participate in making a choice and justifying their response.
    - High-ceiling: All students can improve their justifications.

- How are they implemented?

1. Establish the rules for participation.
    - Instead of having student raise their hands, have them vote by putting the appropriate number of fingers in front of their chest (or, if students have them, use clickers but don't show the results at this point).
    - All students should be required to participate/vote, even if they are not sure if the answer is correct.
2. Display the question and ask students to vote.
    - Wait until all (or nearly all) of the students have voted.
    - Give students a summary of what voting trends you see ("It looks like we are split between two choices" "Wow, people are voting for all of them!").
3. Ask students to discuss their answers with their classmates and make the case for their answer.
    - In a face-to-face class you will know that they are basically done with their discussions when there is a dip in the volume in the room. Listen for that cue.
    - In a synchronous online environment tell students how much time they will have for discussion.
    - In an asynchronous environment consider using a forum option where students can't see other responses until they post their own.

4. Ask students to vote again.
    - See if there is greater consensus. Whether there is or not, move on to the next step, but consider calling on someone with an "incorrect" vote first, if you can identify them.
5. Ask for volunteers to explain why their answer is correct.
    - If someone makes a case for the wrong answer, don't tell them they are wrong, but rather work with the class to identify the misconception and address it. It takes courage to speak up in a case like this, so respect that bravery!

- How do you create them?
    - Use multiple choice questions from the book as a starting point. (These can usually be found in the testbank.)
    - Don't provide more than 5 choices if students are voting with their fingers.
    - Try to ensure that the wrong answers correspond to common misconceptions.
    - This website has many classroom voting question libraries for math classes: http://mathquest.carroll.edu/

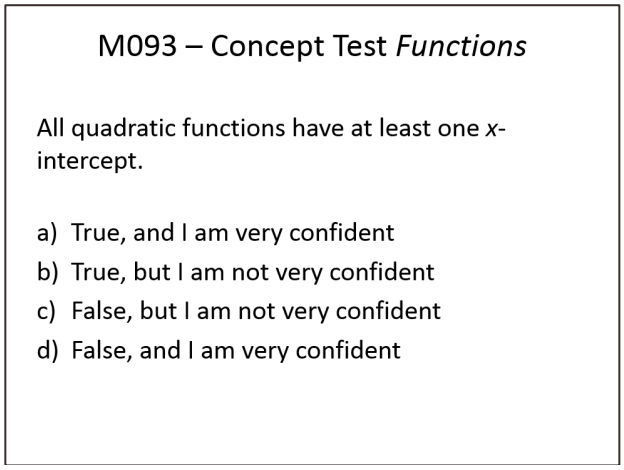
- **Templates:**
    - Multiple choice question
        a) Option 1
        b) Option 2
        c) Option 3
        d) Option 4
        e) I don't know, None of the above, etc.

M091 – Concept Test *Polynomials*

Which of the following shows a pair of like terms?

a) $3x^2$ and $3x$
b) $3x^2$ and $4x^2$
c) $3x^2$ and $2x^3$
d) $3x^2$ and 3
e) None of the above.

- True/False question (tell students that you reserve the right to call on them to justify their answer if they vote "very confident")
    a) True, and I am very confident
    b) True, and I am not confident
    c) False, and I am not confident
    d) False, and I am very confident



- How can they help you make instructional decisions?
    - If all students pick the right answer quickly, you can move on.
    - If students know the answer to a pre-instruction concept check you may be able to decrease the amount of time spent on background or introductory material.
    - If many students vote for a common wrong answer, you have an idea of an important misconception to address.
    - If voting is distributed across all of the choices, you may need to go back and re-visit the topic for clarity.

Equivalence Justifications

- What are they?
    - Students are given a table with several expressions; some are equivalent and others are representative of common misconception.
    - Students decide which are equivalent and give justifications in the space provided.

- What makes them low-floor, high-ceiling?
    - Low floor: All students can participate in making true/false decisions and justifying their responses.
    - High-ceiling: All students can improve their justifications.

- How are they implemented?
    - Have students spend time individually deciding if the expressions are equivalent, and providing justifications. (Think)
    - Have students compare their answers with those of their group members and decide on the correct answer, and a justification. (Pair/Small group)
    - Discuss answers and compare justifications as a class. (Share)

- How do you create them?
    - Look for common (or thought provoking, unusual) errors and misconceptions, perhaps from old exams or homework assignments.

- **Template:**

  Determine whether the following expressions are equivalent to [insert base expression].
  Provide a justification in the space provided.

Expression	Equivalent? Yes/No	Why or Why Not?

- How can they be modified?
    - Ask if equations have the same solutions.

- How can they help you make instructional decisions?
    - Based on the types of justifications (numerical, graphical, verbal) given you can revisit important concepts that may have been missed.
    - This can be an excellent opportunity to introduce the concept of counterexamples, especially if one of the justification strategies involves substituting in values.

Novice to Expert Card Sort

- What are they?
    - A type of attribute activity where students identify "like" objects by defining categories.[1]
- What makes them low-floor, high-ceiling?
    - Low floor: All students can participate, and there are correct sorting schemes that only require a superficial level of understanding.
    - High ceiling: Students can identify multiple sorting schemes based on deeper levels of conceptual understanding.
- How are they implemented?
    - Create a card-sort activity using the novice/expert scheme
    - Give cut-out sets of cards to pairs of students and ask them to sort them.
        - These instructions can be modified based on time, course level, etc.
            - "Sort these cards according to categories that make sense to you."
            - "Sort these cards into four groups according to categories that make sense to you."
            - "Sort these cards into four groups of four according to categories that make sense to you."
    - If a pair finishes early, there are several possible follow-up questions that can be asked:
        - "I claim that these cards can be sorted into four groups of four" (if this was not mentioned in the original instructions and students do not have this sorting already completed).
        - "Can you find a different grouping scheme that also works?"
        - "Which cards were easiest to put together?"
        - "Which cards were the most difficult to put together?"
    - Remember: **As long as a student can justify their grouping scheme, there are no wrong groupings** – just ones that represent different levels and ways of understanding the material
- How do you create them?
    - Create a grid, identify the categories you want to use for "novice" (usually involves surface characteristics) and the categories you want for "expert" (usually involves deeper characteristics).

[1] *Categorization and Representation of Physics Problems by Experts and Novices**, by Chi, Feltovich, and Glaser

    - This is the hardest part, and often requires conversation with colleagues to identify if a category should be considered novice or expert for a particular course.
  - Identify appropriate entries for each intersection of categories.

- **Template:**

	Novice Category 1:	Novice Category 2:	Novice Category 3:	Novice Category 4:
Expert Category 1:	Blank			Error?
Expert Category 2:		Blank		
Expert Category 3:			Blank	
Expert Category 4:				Blank

- How can they be modified?
  - The type of instructions you give students.
    - Most general: "Put these cards into groups that make sense to you"
    - Follow-up for groups that are "done" and have more than four groups: "I claim these cards can be put into four groups."
    - Follow-up #2: "I claim that these cards can be put into four groups of four cards."
    - Leave one blank space for each sort scheme as shown. Ask the students to create an appropriate example for the blank.
      - Don't tell students in advance that there is only one blank for category. This will allow for later prompts to ask students to re-evaluate their categories if they have grouped all of the blank cards together.

    - Can include intentional "error" cards so that students can't identify a group as "all the ones that are left".
        - For example, include a graph with a typo so that it doesn't match the other representations, and ask students how they would fix the graph to make it work.

- How can these help you make instructional decisions?

    - If students are consistently using the "novice" scheme, you may need to go back and help them make explicit connections that would lead to the "expert" scheme.
    - If students are generally using the "expert" scheme, it is probably appropriate to move on to the next topic.
    - Warning: in research the "novice" and "expert" schemes are heavily tested for validity. Remember that your students may not be sorting according to your preconceived schemes not because they don't understand, but because of ineffective card and category design.[2]

References

- Chi, M. T., Feltovich, P. J. and Glaser, R. (1981), Categorization and Representation of Physics Problems by Experts and Novices*. *Cognitive Science*, no. 5: 121-152.
- Wolf, Steven & Dougherty, Daniel & Kortemeyer, Gerd. (2012). Rigging the deck: Selecting good problems for expert-novice card-sorting experiments. *Physics Review Special Topics - Physics Education Research* 8(2)

[2] *Rigging the Deck*, by Wolf, Dougherty, and Kortemeyer