# (Making the Case for) Formative Assessment and Feedback to Support Student Learning in CS Classrooms

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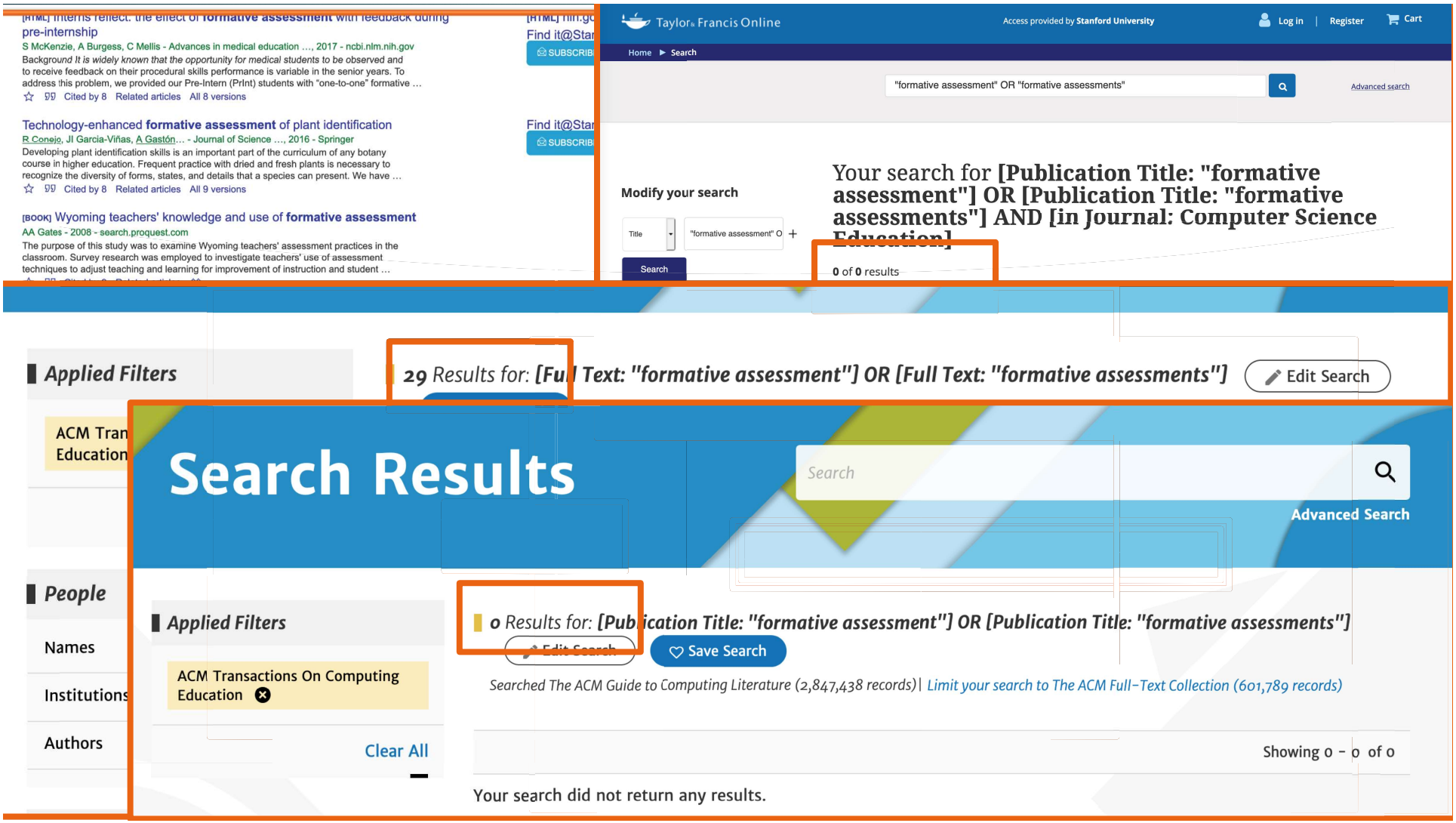
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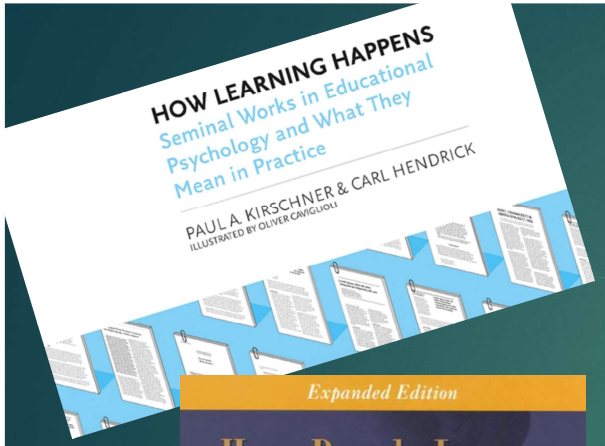
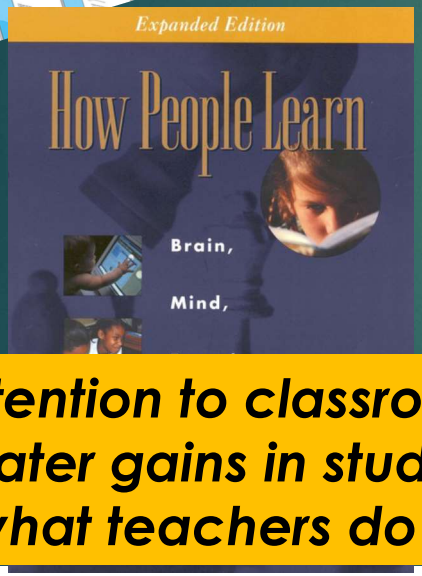
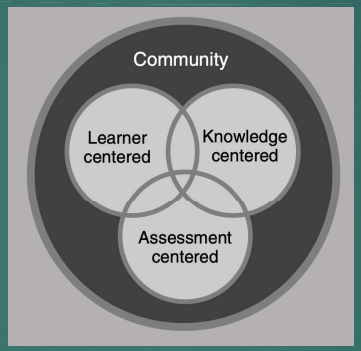



- "possibly the strongest "bet" we know of (Kirschner & Hendrick, 2020)
- "One of the most influential approaches to classroom practice"




- Assessment-centered learning environments provide opportunities for feedback and revision
- **Feedback** is most valuable when students have the opportunity to use it to revise their thinking

***"Attention to classroom formative assessment can produce greater gains in student achievement than any other change in what teachers do" (Wiliam & Leahy, 2012)***

# Outline

- Ten Principles of Formative Assessment (distilled from education research)
  - What is formative assessment?
  - Why is it important?

- Framework of Formative Assessments for computing in schools
  - Design of formative assessments
  - Teacher/Classroom practice (Teacher Preparation, PCK, & formative assessment literacy)
  - Community support for formative assessment

Grover, S. (2021, March). Toward A Framework for Formative Assessment of Conceptual Learning in K-12 Computer Science Classrooms. In *Proceedings of the 52nd SIGCSE Technical Symposium*. ACM.

# What is Formative Assessment?

Paul Black, King's College London,
Dylan Wiliam, Institute of Education,
University of London

*"..all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged." (Black & Wiliam, 1998)*

*"Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited" (Black & Wiliam, 2009)*

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# TEN KEY IDEAS ABOUT FORMATIVE ASSESSMENT (aka what it is & what is it not)

1

Formative Assessment is…

Assessment ***for***, rather than ***of***, learning

*Assessment of Learning is Summative Assessment*

- Assessment FOR Learning (AfL)
- Assessment OF Learning

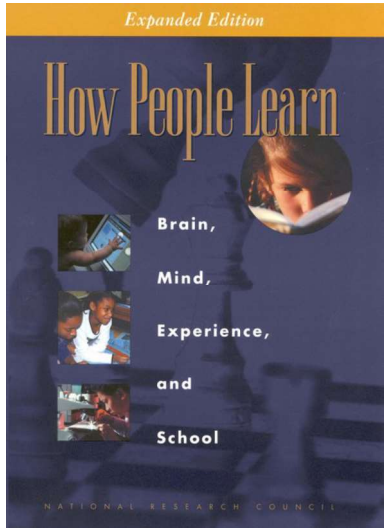
# 2

Formative Assessment is…

ALL about feedback

(Its raison d'etre is to provide evidence & feedback to improve learning)

- Feedback is a key element in assisting the learning process for both instructors and students (Hattie & Timperley, 2007).
  - Formative assessment is not complete until it has resulted in feedback and action on the part of the teacher (or teaching agent) and/or learner
- Feedback provided to the learner impacts:
  - Learner's perception that there may be a gap between goal and where they are at currently and
  - What learners do to close the gap
- Feedback is most valuable when students have the opportunity to use it to revise their thinking as they are working (Bransford, Brown, & Cocking, 2000)



3

Formative Assessment is…

NOT a "test"

NOT aimed at giving students a grade*

(*regardless of CS pedagogy)

- "For some teachers, test is a four-letter word, both literally and figuratively" (W.J. Popham)
- "the best project-based approaches use a combination of ongoing formative assessment and project rubrics that can both communicate high standards and help teachers make judgments about the multiple dimensions of project work" (Barron & Darling-Hammond)
- "We are at the risk of losing the promise of formative assessment for teaching and learning. The core problem lies in the false, but none-the-less widespread, assumption that formative assessment is a particular kind of measurement instrument rather than a process that is fundamental and indigenous to the practice of teaching and learning" (Heritage)

4

Formative Assessment is…

# A Process

- ✓ Teacher: monitoring (*Is learning taking place?*) to diagnosis (*What is learned / not learned?*) to action (*What to do about it?*)
- ✓ Student: *Where am I going? Where am I now? What are my next steps?*

# 5

## A form of regulation

Formative Assessment is…

- At the classroom level
- At the student level, it serves as a way of self-regulation

- Monitoring and external feedback generates internal feedback at a variety of levels (i.e. cognitive, motivational and behavioural) (Nicol & Macfarlane-Dick, 2006)
- A formative interaction is one in which an interactive situation influences cognition, i.e., it is an interaction between external stimulus and feedback, and internal production by the individual learner (*How People Learn*, 2000)
- Classroom assessment guides students' judgment of what is important to learn, affects their motivation and self-perceptions of competence, structures their approaches to personal study, and affects the development of enduring learning strategies and skills (Crooks, 1988)

6

Formative Assessment is…

Critical for sharing learning goals with students

(and what constitutes "good" work)

- If improvement in learning is to take place, students need to come to hold a concept of quality in line with that held by the teacher, and the community (via standards, for example). This growing concept of what "good work" is forms part of the learning itself (Brookhart, 2003)
- Students begin to understand their intended learning goals, develop the skills to make judgments about their learning in relation to a learning standard or instructional outcome, and implement a variety of strategies to regulate their learning.

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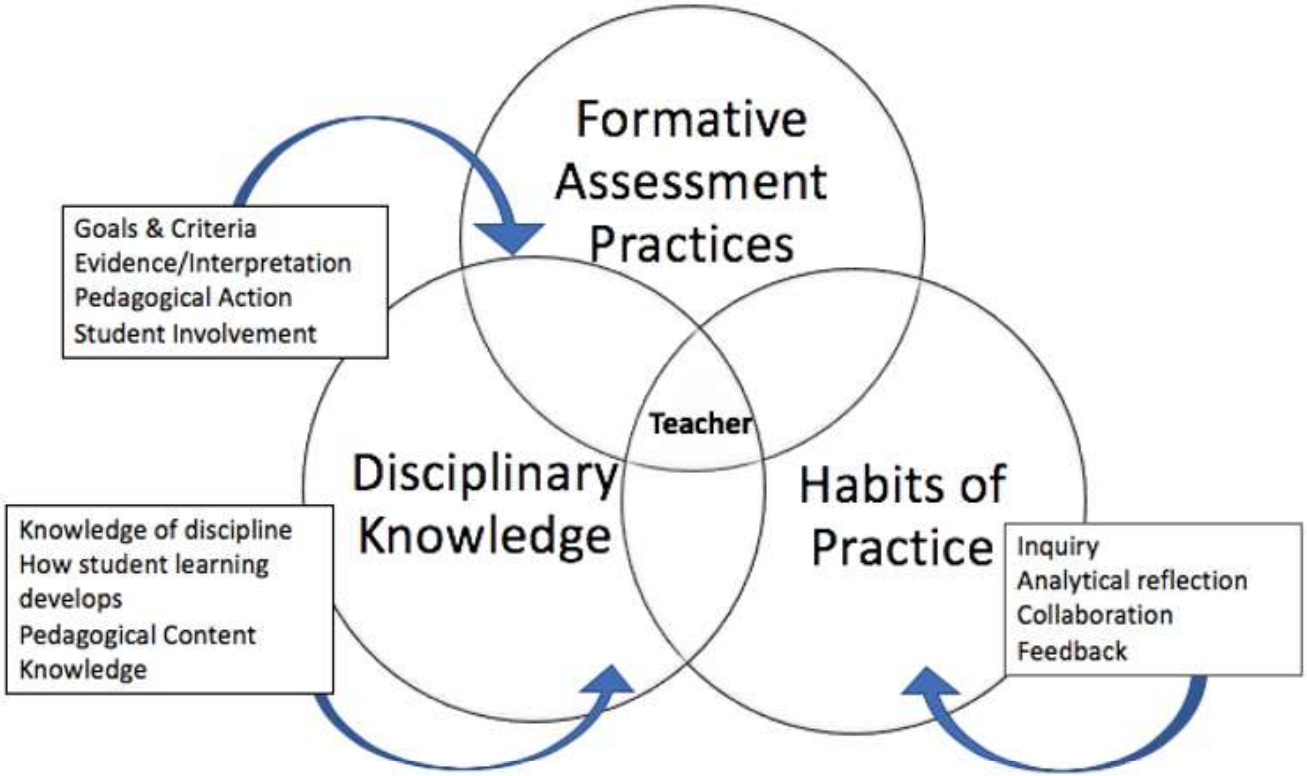
Formative Assessment is…

Closely related to teacher pedagogical content knowledge (PCK)




Heritage & Wylie, 2018

8

Formative Assessment …

Can take many forms
-informal/formal
-Ideally "systems of assessment"


- Observation
- Show of hands
- Peer sharing & explanations
- Informal questions and conversations

CHAPTER 17

# Questions and Inquiry

Shuchi Grover and Steven Floyd

## THE WHAT AND WHY OF QUESTIONS IN A THINKING CLASSROOM

*I have six honest serving horses*
*They taught me all I knew*
*Their names are What, and Where and When;and Why and How and Who.*
– Rudyard Kipling

Questions are central to learning and problem-solving. Not only are they integral to the process by which teachers guide their students in developing their understanding of a topic, they are deeply intertwined with the process through which students extend their learning while exploring concepts. Student and teacher questions can also guide the process of student reflection and 'self-explanation'. Self-explanation has been shown to be valuable to student learning.

Programming is essentially about problem solving. George Pólya's famous problem-solving methodology or technique is book-ended with a series of questions—initially, to understand the problem. and in the end to look back at the process and solution for verification and reflection.

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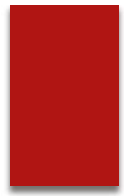
# Formal Formative Assessment



- Quick “Quizzes” (Entry/Exit Tickets/…)
  - Multiple-Choice (MC) and Fixed Answer
  - Other Innovative Item Types
  - Open-Response Types (may need manual grading)
- Programming Assignments (*with Rubrics*)
- Peer and Self-Assessment
- Project Showcase
- Self-Explanation and Reflection (maybe with video)
- Portfolios/Artifact-based Interviews/…

# Formal Formative Assessment

- Quick "Quizzes" (Entry/Exit Tickets/…) with Feedback
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**Formative AfL ONLY if students get timely feedback to revise/correct/ improve**

9

Formative Assessment …

Needs to be speedy & timely

- Teachers' day-to-day classroom practices with an explicit focus on short-cycle assessment have been found to be most impactful
- When teachers want to quickly survey student thinking, an MCQ is efficient
- Large body of CSER literature on design of good MCQ items
- Wiliam & Black (2009) suggest "Moments of Contingency"
  - Critical points where learning changes direction depending on the information gleaned from the assessment

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Formative Assessment …

Provides a way to target known misconceptions

(using "diagnostic items")

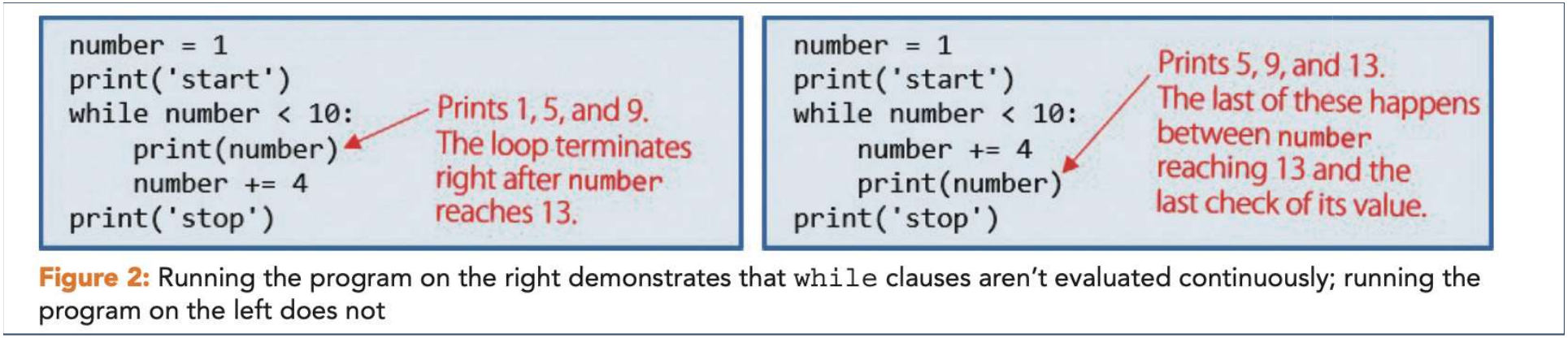



**Figure 2:** Running the program on the right demonstrates that `while` clauses aren't evaluated continuously; running the program on the left does not

Image source: Grover, S. (2020). Computer Science in K-12: An A-Z Handbook on Teaching Programming; Chapter 14 (Sorva, J. Naïve Conceptions of Novice Programmers)

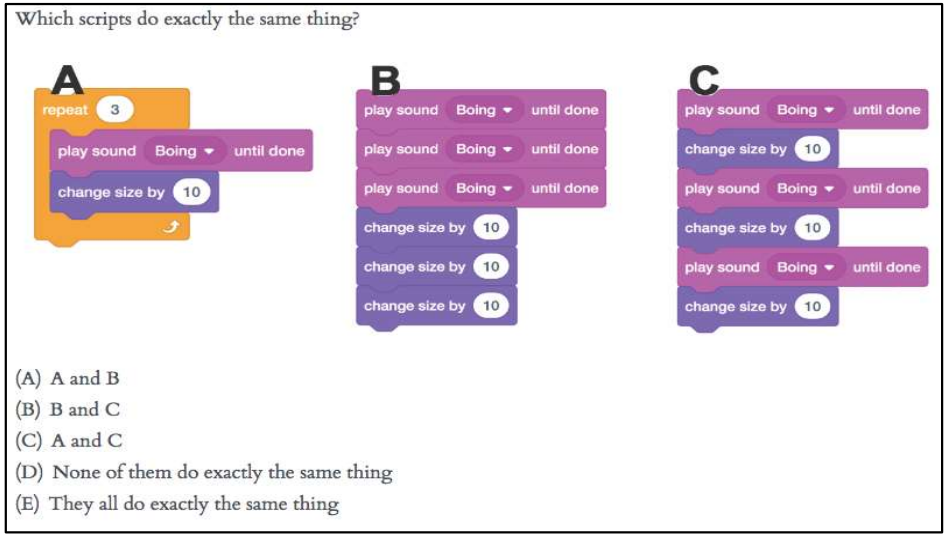



Image source: Grover, S. (2021, March). Toward A Framework for Formative Assessment of Conceptual Learning in K-12 Computer Science Classrooms. In Proceedings of the 52nd SIGCSE Technical Symposium. ACM.

# When you hear the phrase "formative assessment," think…

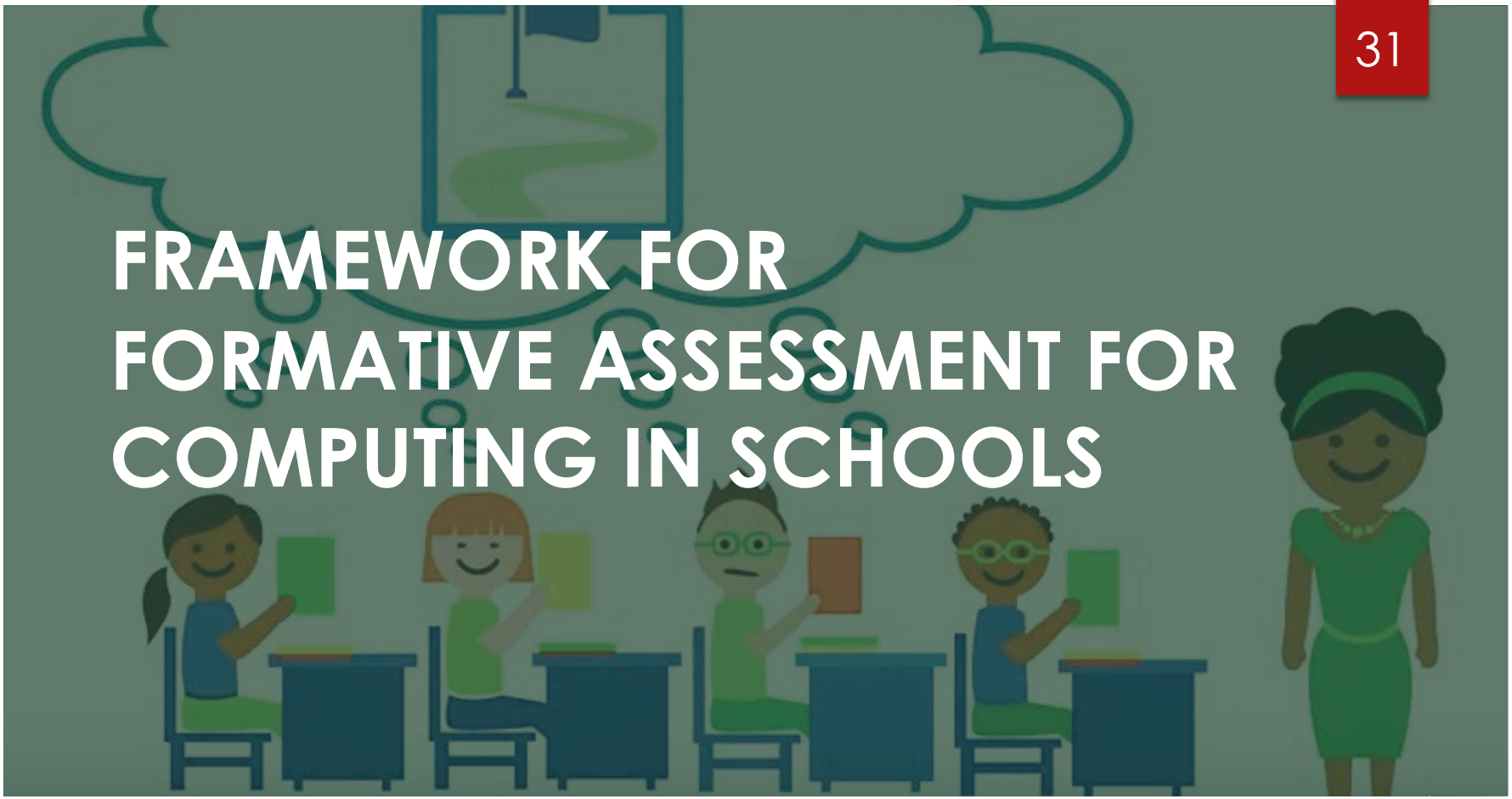
- Feedback
  - No grades (only comments)
- Learning Improvement
- Signal (of learning goals) to student
- Diagnosis (& remedy) of misconceptions
- Short & quick & timely
- Responsive Teaching

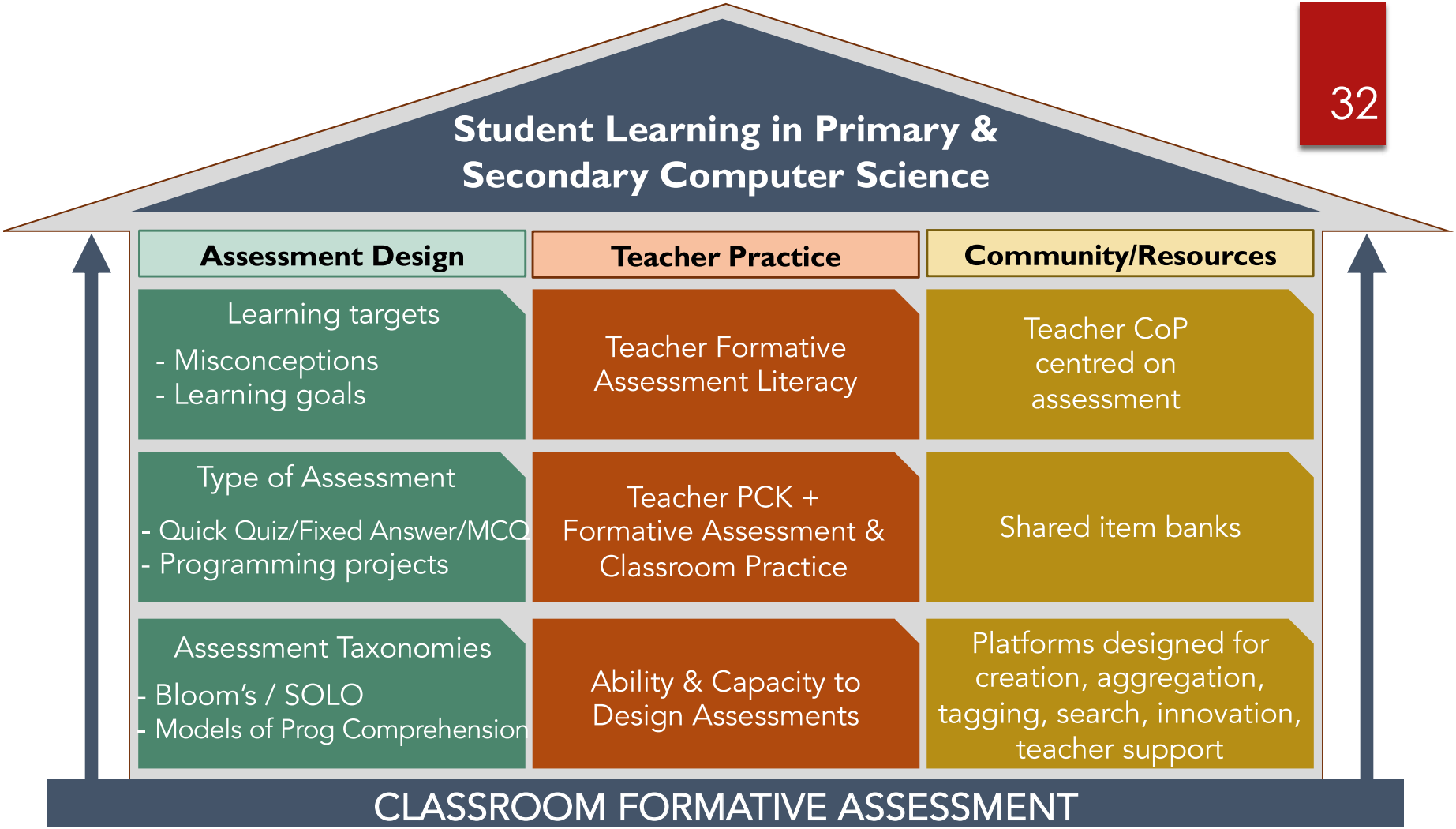
*Feedback should be more for the recipient than the donor*

| Assessment: A Process of Reasoning from Evidence | | | |
|---|---|---|---|
| **Dimension** | **Assessment *for* learning** | **Assessment *of* learning** | |
| **Method** | **Formative Assessment process** | **Classroom Summative/ Interim/Benchmark Assessment** | **Large-scale Summative Assessment** |
| **Purpose** | Assist immediate learning | Measure student achievement/progress ⟺ | Evaluate educational programs |
| **Focus** | Teaching & learning | Measurement | Accountability |
| **Locus** | Individual student & Classroom learning | Classroom/Grade level/ Department/School | School/District/State |
| **Proximity to learning** | Integrated | Middle-distance | Distant |
| **Timing** | *During* instruction | *After* teaching-learning cycle → Between instructional units/calendar periods | End of year/course |
| **Participants** | Teacher & Student (T-S / S-S / Self) | Student | Student |

(Source: CCSSO, 2014)

# FRAMEWORK FOR FORMATIVE ASSESSMENT FOR COMPUTING IN SCHOOLS



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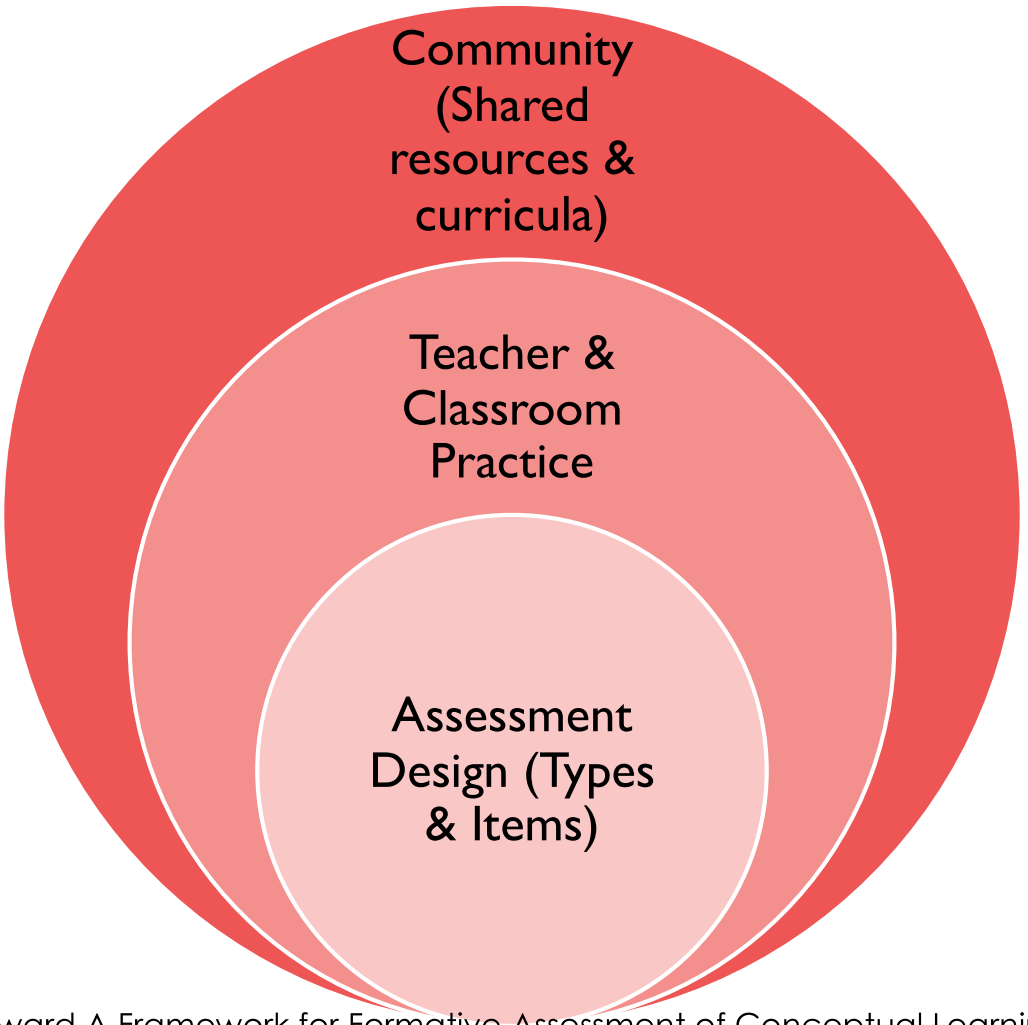


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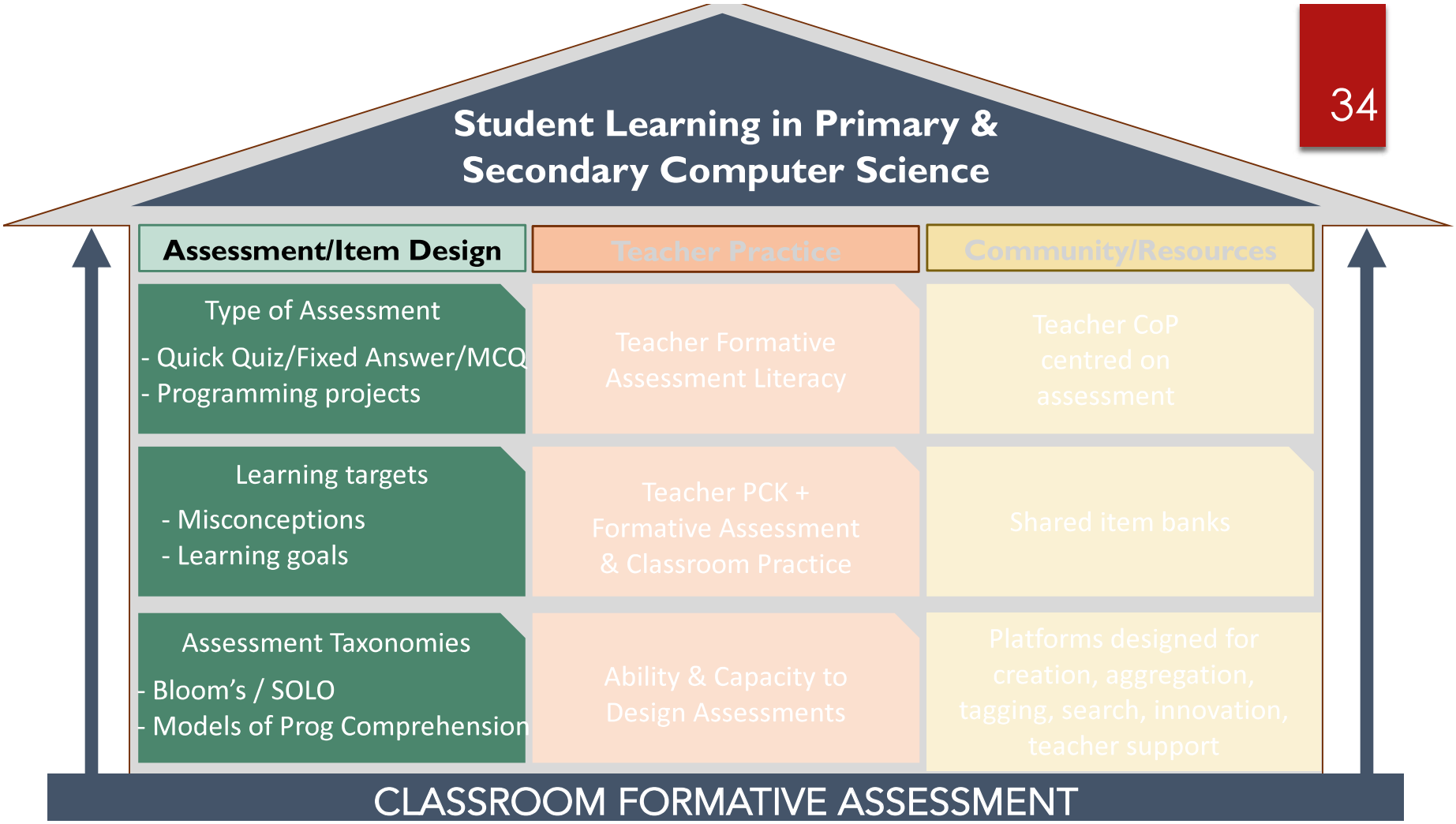


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# Variety of Formative Assessment "Systems of Assessment" (Grover, 2017)

- Teacher Observation / Q&A with students
- Programming Assignments
- Quick Quizzes
  - Multiple-Choice (MC) and Fixed Answer
  - (Other) Innovative Item Types
  - Open-Response Types (need manual grading)
- Project Showcase with Peer and Self-Assessment
- Self-Explanation and Reflection (maybe with video)
- Portfolios/Artifact-based Interviews/...

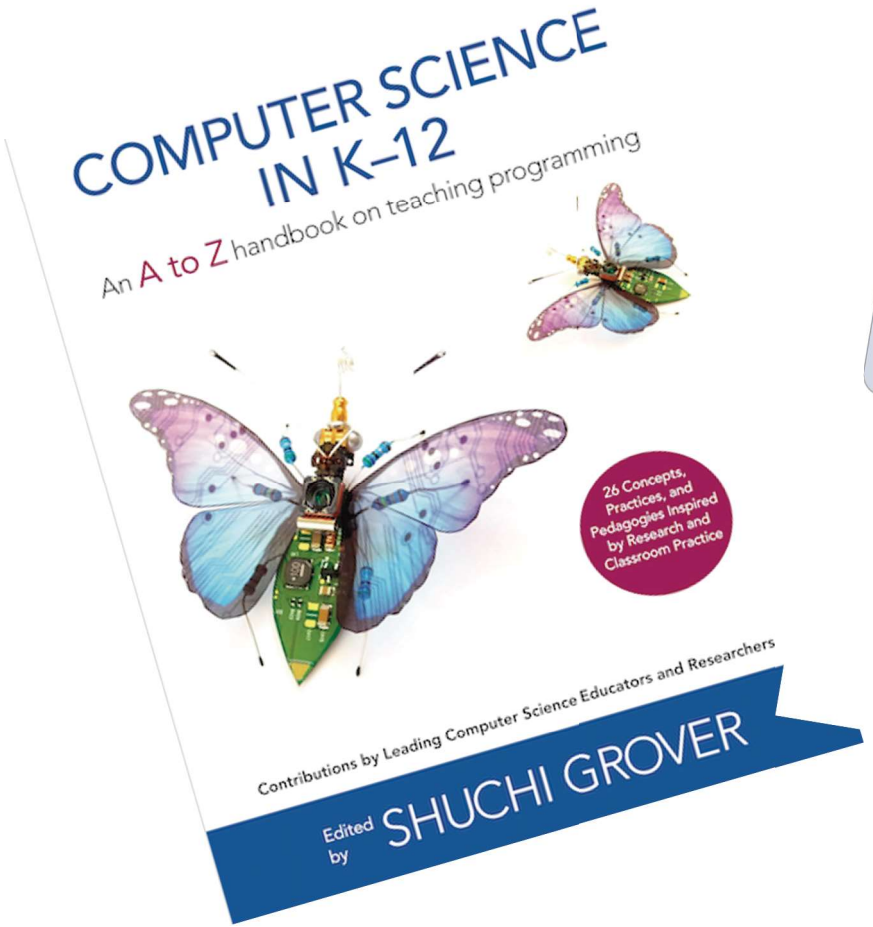
# "Systems of Assessment" (Grover, 2017)

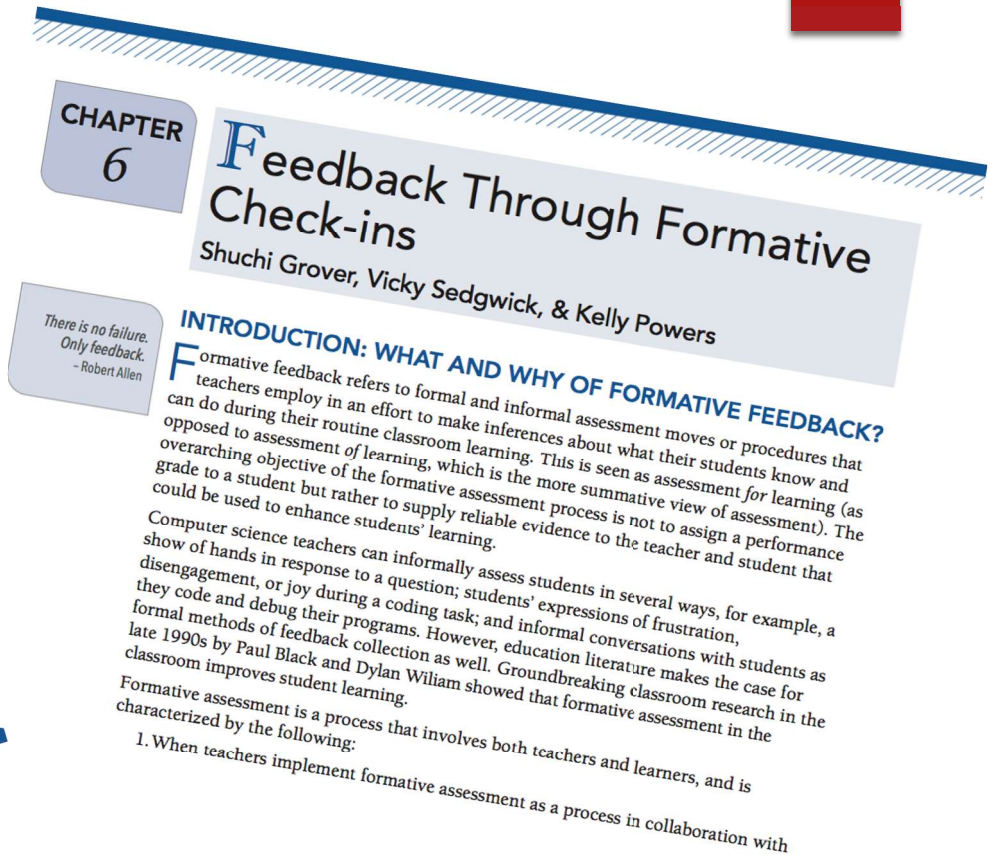
Deeper learning goals include

- **Cognitive** – disciplinary concepts, problem-solving & thinking skills and practices
- **Interpersonal** – communication, collaboration, …
- **Intrapersonal** – interest, identity, motivation, persistence, mindsets, …

Various forms of assessment that target these multi-faceted goals for CS learning

# Types (& Examples) of Formative Assessment



CHAPTER 6

## Feedback Through Formative Check-ins

Shuchi Grover, Vicky Sedgwick, & Kelly Powers

*There is no failure. Only feedback.*
– Robert Allen

### INTRODUCTION: WHAT AND WHY OF FORMATIVE FEEDBACK?

Formative feedback refers to formal and informal assessment moves or procedures that teachers employ in an effort to make inferences about what their students know and can do during their routine classroom learning. This is seen as assessment *for* learning (as opposed to assessment *of* learning, which is the more summative view of assessment). The overarching objective of the formative assessment process is not to assign a performance grade to a student but rather to supply reliable evidence to the teacher and student that could be used to enhance students' learning.

Computer science teachers can informally assess students in several ways, for example, a show of hands in response to a question; students' expressions of frustration, disengagement, or joy during a coding task; and informal conversations with students as they code and debug their programs. However, education literature makes the case for formal methods of feedback collection as well. Groundbreaking classroom research in the late 1990s by Paul Black and Dylan Wiliam showed that formative assessment in the classroom improves student learning.

Formative assessment is a process that involves both teachers and learners, and is characterized by the following:

1. When teachers implement formative assessment as a process in collaboration with

| Assessment Type | Examples / Details |
| --- | --- |
| **Programming Assignments**<br>• *Engaging and motivating*<br>• *Usually time-consuming to score (and subjective)*<br>• *Do not provide quick feedback*<br>• *Must be accompanied with rubrics for teachers and students*<br>• *Difficult to interpret for formative action (Presence of construct may not = understanding)*<br><br>*Modality: programming environment* | • Open project with specific criteria<br>  • **Example 1: My Project** has at least two sprites engaged in a conversation.<br>  • **Example 2: My Project** uses blocks to change the appearance to match different backdrops in a story.<br>• Closed-ended programming assignment with a desired end goal<br>• Debugging buggy code<br>• Complete a partially coded programming project |

Image source: Computer Science in K-12: An A-Z Handbook on Teaching Programming; Chapter 6.

| Assessment Type | Examples / Details |
| --- | --- |
| **Showcasing \| Peer & Self Assessment**<br>• *Help assess collaboration and communication*<br>• *Can be engaging as they involve the whole-class or peer groups*<br>• *Usually time-consuming for teacher feedback*<br><br>*Modality: physical space; video/audio* | • Explanations - these could be written or oral or audio/video recorded that accompany students' code about their programming project<br><br>• Code comments<br><br>• Show & Tell: project presentations to share various aspects of the project |

Image source: Computer Science in K-12: An A-Z Handbook on Teaching Programming; Chapter 6.

| | |
|---|---|
| **Video/Audio Self Explanation & Reflection**<br>• *Aid reflection and ipsative assessment— assessment as learning*<br>• *Time-consuming*<br>• *Impractical for teacher to monitor*<br><br>*Modality: pen-paper or online* | • Reflective journals to track progress on a large project<br>• Reflective prompts that reveal learner experience— thrills, frustrations & difficulties, collaboration; other aspects of learning |
| **Artifact-based Interviews** | • Conversation with teacher about a project |

Image source: Computer Science in K-12: An A-Z Handbook on Teaching Programming; Chapter 6.

| Assessment Type | Examples / Details |
| --- | --- |
| **Quizzes: Open Response Types**<br>• *Not autogradable*<br>• *Provide deeper insights into learner understanding*<br>• *Time-consuming and subjective to score*<br><br>*Modality: pen-paper or online* | • Quiz- like prompts involving code snippets that require open-ended responses probing for explanations or descriptions of what a code snippet does |

Image source: Computer Science in K-12: An A-Z Handbook on Teaching Programming; Chapter 6.

| Assessment Type | Examples / Details |
| --- | --- |
| **Quizzes: Multiple Choice / Fixed Answer**<br>• *Usually autogradable*<br>• *Good for quick feedback on student understanding*<br>• *Can surface learner difficulties*<br>• *More test-like and not very engaging for students*<br><br>*Modality: pen-paper or online* | • Present code snippets that require students to demonstrate code-comprehension skills.<br>  • A program with "fill-in-the-blank" slots (fixed response or choose from options for the blanks)<br>  • Analyze and compare programs<br>  • Determine whether a piece of code meets its goal<br>  • Multiple-choice (MC) options to fix buggy code<br>  • MC options for an expression for a conditional/loop<br><br>• Present a programming requirement in text<br>  • MC options to pick the correct solution |

Image source: Computer Science in K-12: An A-Z Handbook on Teaching Programming; Chapter 6.

| Assessment Type | Examples / Details |
| --- | --- |
| **Quizzes: Innovative Item Types**<br>• *Usually autogradable*<br>• *Can surface learner difficulties*<br>• *Good for quick feedback*<br>• *More engaging than multiple-choice items*<br>*Modality: pen-paper or online* | • Parson's problems or puzzles (rearranging provided code blocks or commands in correct sequence)<br>• Hotspot items<br>• Unit-tested coding (autograded)<br>• Match options in two columns<br>• Microworlds for students to create constrained fixed outcome programming (a la Hour of Code puzzles) |

Image source: Computer Science in K-12: An A-Z Handbook on Teaching Programming; Chapter 6.

- Teacher Observation
- Quick Quizzes
  - Multiple-Choice (MC) and Fixed Answer
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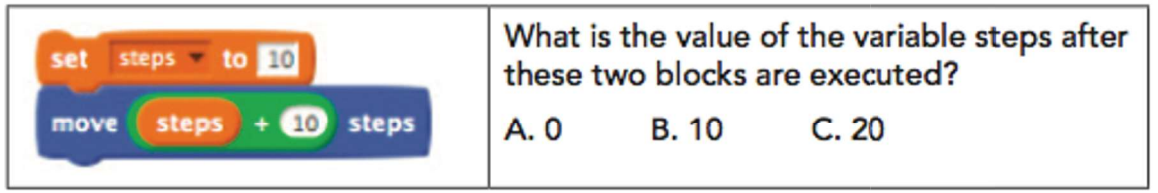
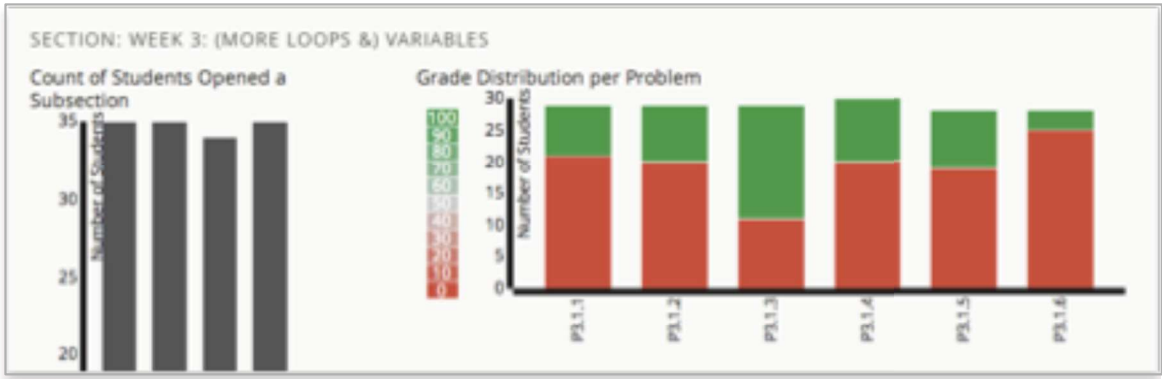
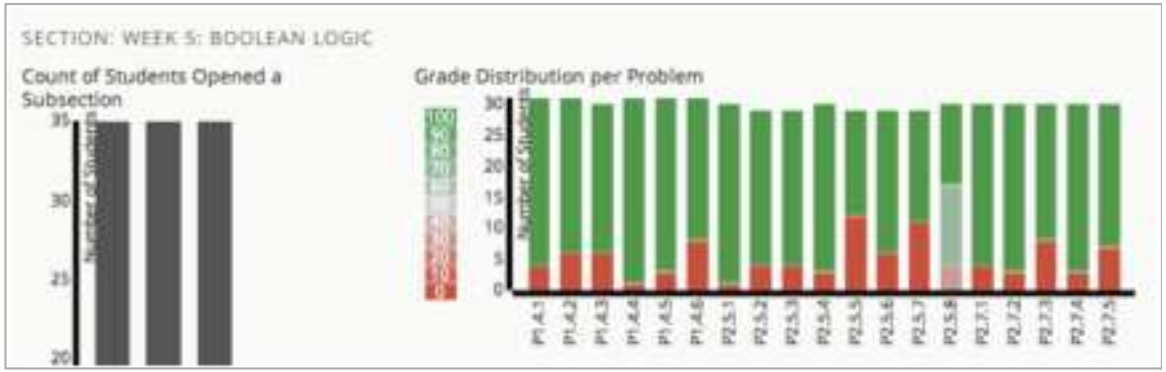
Teachers' day-to-day classroom practices with an explicit focus on short-cycle assessment are most impactful (Wiliam, 2009)

MCQs can target CS and programming concepts, semantics & syntax, knowledge components, as well as practices (such as debugging, design, decomposition,..)



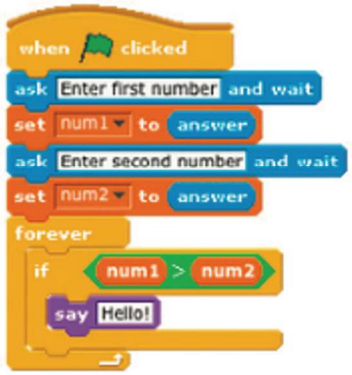




(Grover, Pea & Cooper, Learning@Scale, 2014)

# Students' reactions to quizzes (Grover, 2014)

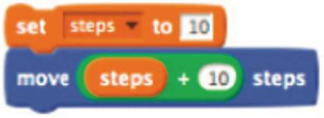
- "when you get a wrong answer and read the solution, sometimes you just have "oooooooooooh" moment and it helps you further understand the topic"
- "I feel that the quizzes are a great part to enhance learning, but maybe put some extra quizzes?"
- "The quizzes well tested the concepts in the videos"
- "they have good questions in them"
- "The quizzes helped me understand what was common mistakes are and how I can fix them."
- "Quizzes are one of my least favorite things about the course. I felt like scratch assignments helped me learn and understand concepts far more than a quiz ever did."
- "I think their should have been less quizzes"

# MCQ of Varied Types




When the code on the left is executed, for which pair of inputs will the sprite say "Hello"?

- ❑ num1 = 5, num2 = 8
- ❑ num1 = 3, num2 = 9
- ❑ num1 = 8, num2 = 8
- ❑ num1 = 7, num2 = 6

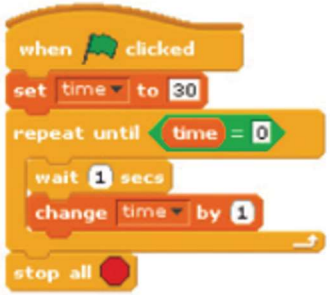



What is the value of the variable steps after these two blocks are executed?

A. 0 B. 10 C. 20

Evaluate the Boolean expression.


Raul wants to make a timer that will count down from 30 to 0. Raul has written the following code using a time variable:




(1) Will Raul's code work as desired? Yes / No

(2) In Raul's code, will the Repeat Until loop ever stop (i.e., will the "time=0" condition ever be satisfied?)? Yes / No

(3) If you had to change *just one thing* to fix the bug, what would you change?

- ❑ The `Set` time block
- ❑ The `Repeat Until` "time=0" condition
- ❑ The `wait` block
- ❑ The `change` time `by` block
- ❑ The `stop all` block

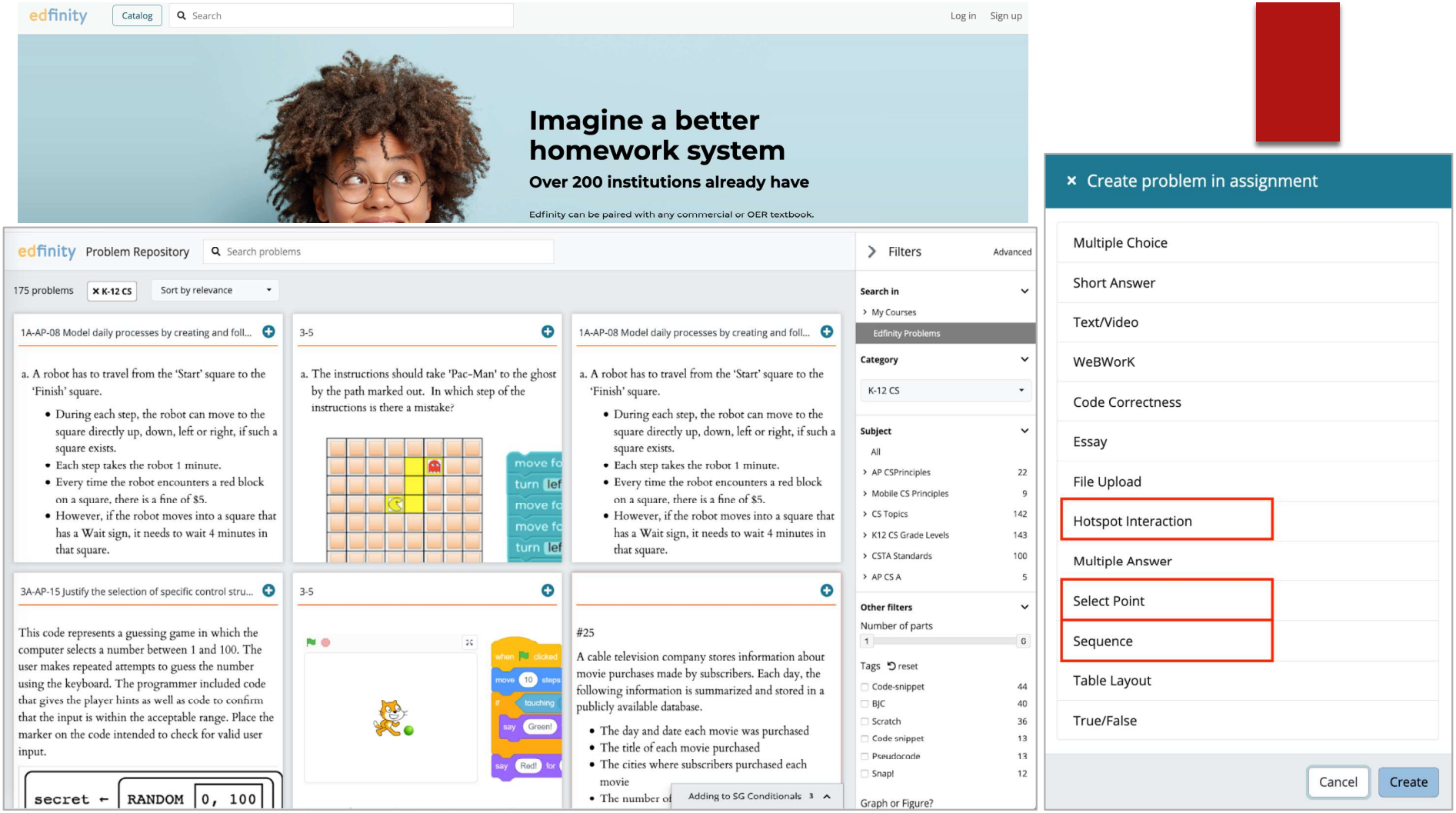
| Question Type | Description/Example |
|---|---|
| Fixed code | Manually trace through some code and select the correct outcome or result from a set of options |
| Determine correctness | Given a goal, determine whether a code snippet achieves the goal (requires code tracing) |
| Compare solutions | Given two or more solutions, pick correct option; or evaluate which is better based on given criteria |
| Specify variable value | Trace code to determine what the value of variable(s) at a specified point or at the end |
| Skeleton code | Requires selection of code (from a set of options) that completes the provided "skeleton" code, |
| Change in logic | Given a code fragment, select from options the code fragment(s) that should give the same result but the logic of the algorithm has been altered (or reversed). |
| Change in representation | Given an algorithm in pseudo code (or natural language) translate the logic into code in language X (or vice versa). |
| Code purpose | Given a code segment, explain the purpose of that piece of code in plain English (or select from options) |
| Code refactoring | Given a code snippet, select options for refactoring or click on code chunks suitable for refactoring. |
| Parson's problems | Given a goal, rearrange blocks (of code) to achieve the given goal |
| Debug/Fix Code | Given a goal, identify bug by selecting from options or clicking on blocks or lines of code; or selecting what would fix the code |
| Code intent | From a test case or series of test cases, determine the intent, the code for which this test specifies the functional intent. |

BONUS: Underscores teaching of code reading, code tracing and code comprehension.

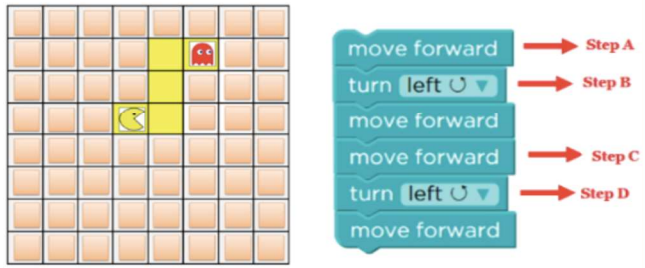
Builds on and expands extensive prior work in CSER. For example,

- Schulte, C., Clear, T., Taherkhani, A., Busjahn, T., & Paterson, J. H. (2010). An introduction to program comprehension for computer science educators. In Proceedings of the 2010 ITiCSE working group reports (pp. 65-86).
- Whalley, J.L. and Robbins, P. 2007. Report on the fourth BRACElet workshop. Bulletin of Applied Computing and Information Technology. 5, 1 (Jun. 2007).
- Sheard, J., Carbone, A., Chinn, D., Laakso, M. J., Clear, T., de Raadt, M., ... & Warburton, G. (2011, August). Exploring programming assessment instruments: a classification scheme for examination questions. In Proceedings of the seventh international workshop on Computing education research (pp. 33-38).

Image Source: Grover, S. (2021, March). Toward A Framework for Formative Assessment of Conceptual Learning in K-12 Computer Science Classrooms. In Proceedings of the 52nd SIGCSE Technical Symposium. ACM.


edfinity
Catalog
Search
Log in
Sign up
Imagine a better homework system
Over 200 institutions already have
Edfinity can be paired with any commercial or OER textbook.
edfinity Problem Repository
Search problems
175 problems
K-12 CS
Sort by relevance
1A-AP-08 Model daily processes by creating and foll...
a. A robot has to travel from the 'Start' square to the 'Finish' square.
During each step, the robot can move to the square directly up, down, left or right, if such a square exists.
Each step takes the robot 1 minute.
Every time the robot encounters a red block on a square, there is a fine of $5.
However, if the robot moves into a square that has a Wait sign, it needs to wait 4 minutes in that square.
3-5
a. The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a mistake?
1A-AP-08 Model daily processes by creating and foll...
a. A robot has to travel from the 'Start' square to the 'Finish' square.
During each step, the robot can move to the square directly up, down, left or right, if such a square exists.
Each step takes the robot 1 minute.
Every time the robot encounters a red block on a square, there is a fine of $5.
However, if the robot moves into a square that has a Wait sign, it needs to wait 4 minutes in that square.
3A-AP-15 Justify the selection of specific control stru...
This code represents a guessing game in which the computer selects a number between 1 and 100. The user makes repeated attempts to guess the number using the keyboard. The programmer included code that gives the player hints as well as code to confirm that the input is within the acceptable range. Place the marker on the code intended to check for valid user input.
secret ← RANDOM 0, 100
3-5
#25
A cable television company stores information about movie purchases made by subscribers. Each day, the following information is summarized and stored in a publicly available database.
The day and date each movie was purchased
The title of each movie purchased
The cities where subscribers purchased each movie
Adding to SG Conditionals 3
Filters
Advanced
Search in
My Courses
Edfinity Problems
Category
K-12 CS
Subject
All
AP CSPrinciples 22
Mobile CS Principles 9
CS Topics 142
K12 CS Grade Levels 143
CSTA Standards 100
AP CS A 5
Other filters
Number of parts
Tags reset
Code-snippet 44
BJC 40
Scratch 36
Code snippet 13
Pseudocode 13
Snap! 12
Graph or Figure?
Create problem in assignment
Multiple Choice
Short Answer
Text/Video
WeBWorK
Code Correctness
Essay
File Upload
Hotspot Interaction
Multiple Answer
Select Point
Sequence
Table Layout
True/False
Cancel
Create

a. The instructions should take 'Pac-Man' to the ghost by the path marked out. In which step of the instructions is there a mistake?




Select the step in which there is a mistake.

(A) Step A
(B) Step B
(C) Step C
(D) Step D

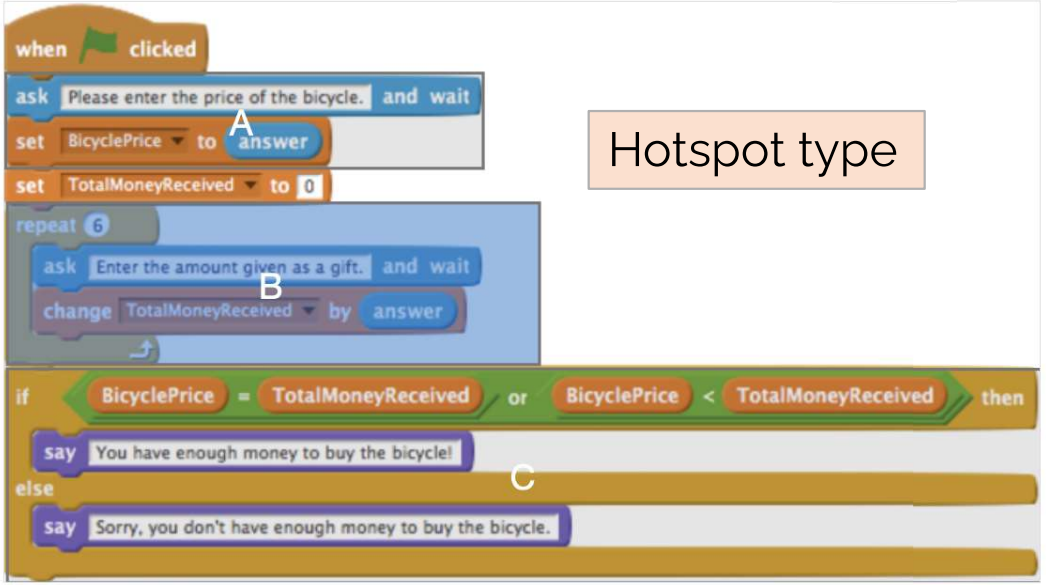
b. The instructions should take 'Pac-Man' to the ghost by the path marked out.

Click which step of the instructions below is a mistake.


Select point (point & click one or more)

a. The program has been divided into 3 sections (A, B, C). Click the part that --

Sums up the amount of money that Kayla receives from her uncles

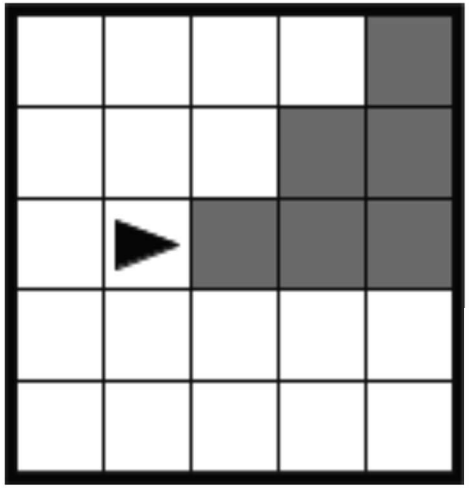



Hotspot type

Increase engagement and reduce cognitive load with innovative problem types

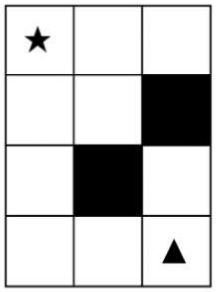
b. Click the square the robot will occupy once the code segment is finished running.

```
IF (CAN_MOVE ( left ))
{
 ROTATE_LEFT ()
 MOVE_FORWARD ()
}
IF (CAN_MOVE ( left ))
{
 ROTATE_LEFT ()
 MOVE_FORWARD ()
}
IF (CAN_MOVE ( left ))
{
 ROTATE_LEFT ()
 MOVE_FORWARD ()
}
```



Select point (point & click one or more)

Rearrange the instructions provided so the robot in the bottom right corner which is currently facing North will reach the star in the top left corner of the grid without running into any walls or obstacles, indicated by black squares in the grid.



*Drag blocks from here*

```
MOVE_FORWARD()
REPEAT 2 TIMES
REPEAT 3 TIMES
ROTATE_RIGHT()
MOVE_FORWARD()
ROTATE_LEFT()
```

Parson's Problem (Sequence)

Increase engagement and reduce cognitive load with innovative problem types

# Targeting misconceptions & known novice difficulties through "diagnostic items"


- Diagnostic questions (or items) target known student misconceptions /difficulties.
- 3+ decades of research on novice learner misconceptions
  - Sorva (2020) lists about 40+ known novice misconceptions
- Known difficulties, e.g. learners struggle with constructing a loop terminating condition (esp if it involves variables & combinations of logical & relational operators

```
repeat until <condition>
{
}
```

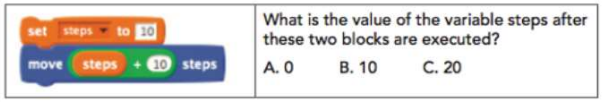
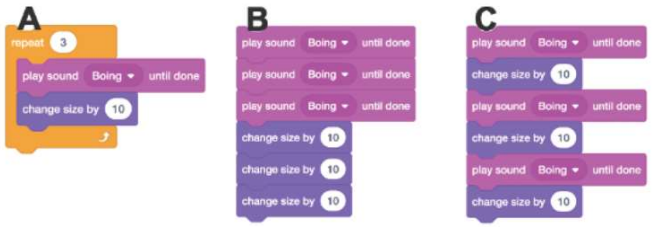
| Problems targeting misconceptions | Concepts targeted | What does the student not understand? | What are possible next moves for the teacher? |
|---|---|---|---|
|  <br>What is the value of the variable steps after these two blocks are executed?<br>A. 0 B. 10 C. 20<br>Many students respond with 20 as the answer | Variable assignment | S does not understand that only set/change blocks will affect the value of a variable | Share examples (a) with variable inspection when variable values change; (b) of how expressions evaluate to a value |
| Which scripts do exactly the same thing?<br>  <br>(A) A and B<br>(B) B and C<br>(C) A and C<br>(D) None of them do exactly the same thing<br>(E) They all do exactly the same thing | Simple loops (targets "repeating unit" misconception [23]) | They do not understand that the commands in a loop repeat as a repeating unit | Examples that trace and "unfurl" a loop<br>Multiple examples with different "repeating units" that help visualize the execution of a group of commands in various ways (sound, print/say, costume chance)<br>VELA "graphical looping" activity |
| `number=1`<br>`print('start')`<br>`while(number < 10:`<br>`  number += 4`<br>`  print(number)`<br>`print('stop')`<br>**(A)**<br><br>`number=1`<br>`print('start')`<br>`while(number < 10:`<br>`  print(number)`<br>`  number += 4`<br>`print('stop')`<br>**(B)**<br><br>(1) Do A and B print the same values?<br>(2) What are the numbers printed in each?<br>(3) What is the value of 'number' after the loop? | How while loops work; how variables are update; how variable expressions control loops [46] | Some students believe the while loop is continuously checked. | Have students trace the code and write down values for both and compare behaviors. |

Image Source: Grover, S. (2021, March). Toward A Framework for Formative Assessment of Conceptual Learning in K-12 Computer Science Classrooms. In Proceedings of the 52nd SIGCSE Technical Symposium. ACM.

# Learning trajectories & (granular) learning goals; Guided by models of program comprehension & assessment taxonomies

- Formative Assessment is tied to learning goals – in the moment / on the day
- Granular learning goals that build toward bigger understandings could become AfL targets
- Assessment items should be informed by granular learning goals outlined in learning progressions and trajectories (Rich et al., 2017, 2018, 2019)
- For example, the Block model (Izu et al.,2019; Schulte, 2008) provides guidance on granularity of programming skills
- SOLO Taxonomy; Blooms Taxonomy

# THE BLOCK MODEL

| | | | |
|---|---|---|---|
| **(M) Macro structure** | Understanding the overall structure of the program text | Understanding the algorithm underlying a program | Understanding the goal/purpose of the program in the current context |
| **(R) Relationships** | Relationships between blocks | Sequence of function calls, object sequence diagrams | Understanding how subgoals are related to goals |
| **(B) Blocks** | Regions of interest that build a unit (syntactically or semantically) | Operation of a block or function | Understanding of the function of a block of code |
| **(A) Atoms** | Language elements | Operation of a statement | Function of a statement |
| | **(T) Text surface** | **(P) Program execution** | **(F) Function** |
| | **Architecture/Structure** | | **Relevance/Intention** |

(Schulte, 2008; Izu et al., 2019)

*Image source: Sentence, S., 2020 (Hello World, Issue 14)*

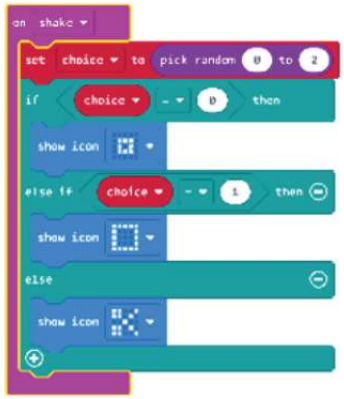
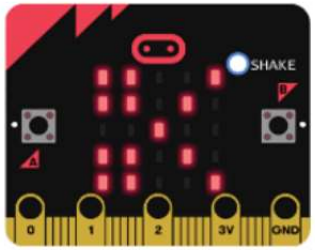
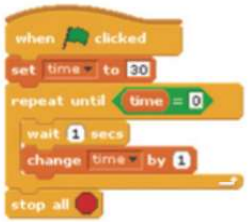
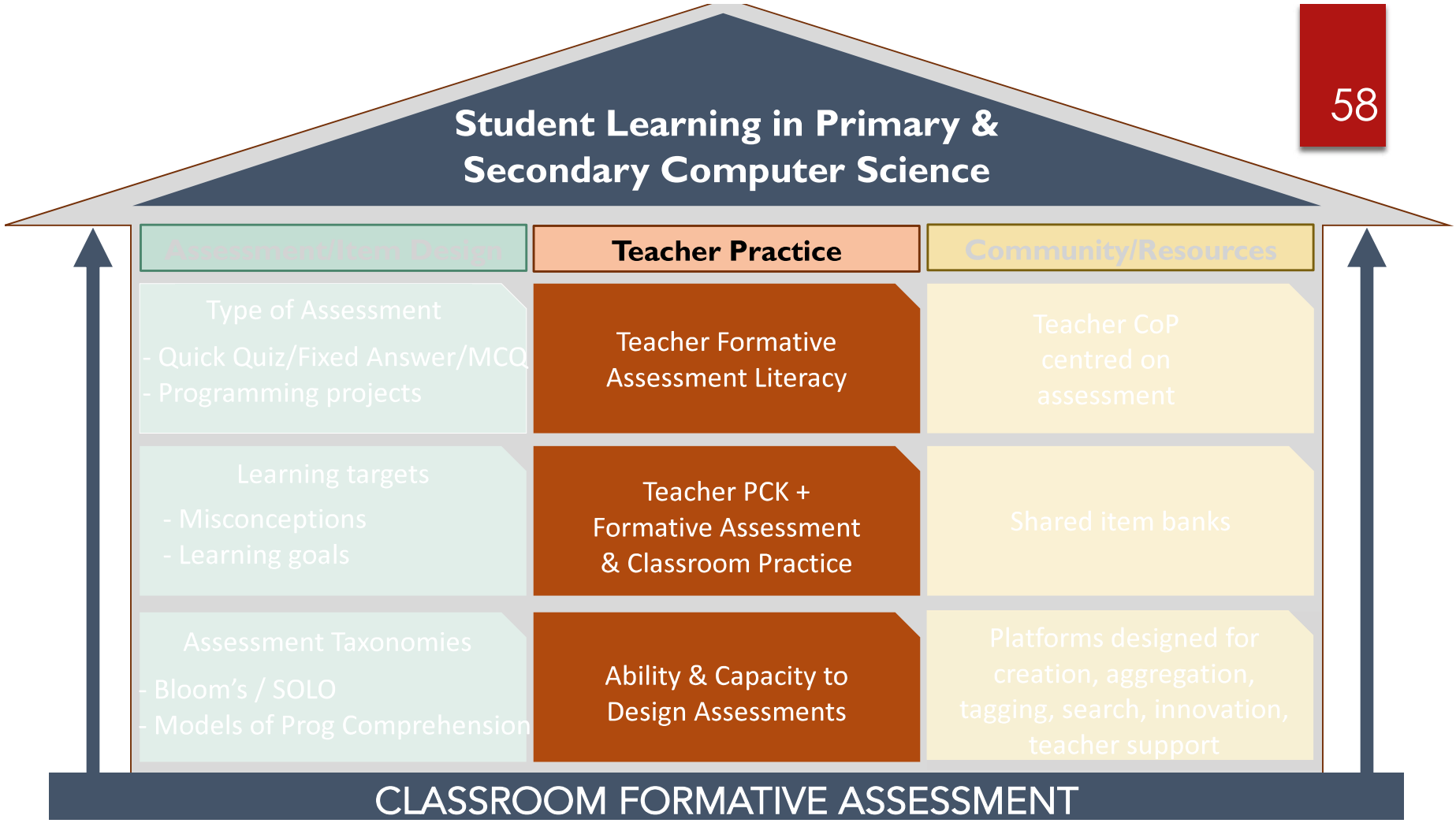
| Problems using learning trajectories and using building blocks of comprehension (Block Model) | Concepts targeted | What does the student not understand? | What are possible next moves for the teacher? |
|---|---|---|---|
|  <br>  <br>The program on the left has been flashed onto the micro:bit. When the micro:bit is shaken, it displays the icon shown above. **What value is stored in the choice variable?** | Nested If-Else statements | How control flow works in code with nested IF-Then-Else statements | Break it down into a simple IF-Else conditional first and demonstrate control flow. Then add the nested IF-THEN and step-by-step help trace the code to see what the 'K' suggests about the value in the 'choice' variable |
| Raul wants to make a timer that will count down from 30 to 0. Raul has written the following code using a time variable:<br>  <br>(1) Will Raul's code work as desired? Yes / No<br>(2) In Raul's code, will the Repeat Until loop eve stop (i.e., will the "time=0" condition ever b satisfied?)? Yes / No<br>(3) If you had to change *just one thing* to fix the bug, what would you change?<br>❑ The `Set` time block<br>❑ The `Repeat Until` "time=0" condition<br>❑ The `wait` block<br>❑ The `change time by` block<br>❑ The `stop all` block | - Controlling a loop with a variable [38]<br>- Configuring a condition to stop the loop<br>- Variable initialization and updating | Break down the concepts to isolate problem from among the possible ones. | This question should not be given as a formative assessment in primary or middle grades as it addresses the relational level of the Block Model. |

Image Source: Grover, S. (2021, March). Toward A Framework for Formative Assessment of Conceptual Learning in K-12 Computer Science Classrooms. In Proceedings of the 52nd SIGCSE Technical Symposium. ACM.

# THE BLOCK MODEL

| | | | |
|---|---|---|---|
| **(M) Macro structure** | | | 2. Ask: "What would happen if the input to the program was ___?" |
| **(R) Relationships** | 5. Ask students to identify the scope of a variable | 4. Draw the flow of control on the program | |
| **(B) Blocks** | 3. Ask students to draw on the program to identify blocks of code or types of construct | 1. Ask: "What would happen if those two lines were the other way around?"<br>4. Draw the flow of control | |
| **(A) Atoms** | | | 6. Identify the purpose of a single statement |
| | **(T) Text surface** | **(P) Program execution** | **(F) Function** |
| | **Architecture/Structure** | | **Relevance/Intention** |

*Image source: Sentence, S., 2020 (Hello World, Issue 14)*


Student Learning in Primary & Secondary Computer Science
Assessment/Item Design
Teacher Practice
Community/Resources
Type of Assessment
- Quick Quiz/Fixed Answer/MCQ
- Programming projects
Teacher Formative Assessment Literacy
Teacher CoP centred on assessment
Learning targets
- Misconceptions
- Learning goals
Teacher PCK + Formative Assessment & Classroom Practice
Shared item banks
Assessment Taxonomies
- Bloom's / SOLO
- Models of Prog Comprehension
Ability & Capacity to Design Assessments
Platforms designed for creation, aggregation, tagging, search, innovation, teacher support
CLASSROOM FORMATIVE ASSESSMENT

# Teacher Preparation / Assessment Literacy

The practice of assessment to improve learning has always been at the heart of good educators' practice – this is not entirely new; *however CS is a new subject!*

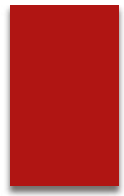
Issues:

- Formative assessment is not well understood by most teachers; and CS teachers especially, suggest that it is something they need help with (Vivian & Falkner, 2018)
- External pressures of accountability get in the way
- Requires change in teachers' perception of their own role & their classroom practice

Suggested Ideas:

- ✓ Focus on the ***what*** and then the ***how***
  - ✓ Students benefit only when teachers change what they ***do*** in classrooms, and not based on what they ***think***
- ✓ Build assessment measures of teacher assessment literacy that consider the introductory CS context and include factors shown to influence classroom assessment (Vivian & Falkner, 2018; DeLuca et al., 2016)

# Transform Classroom Practice



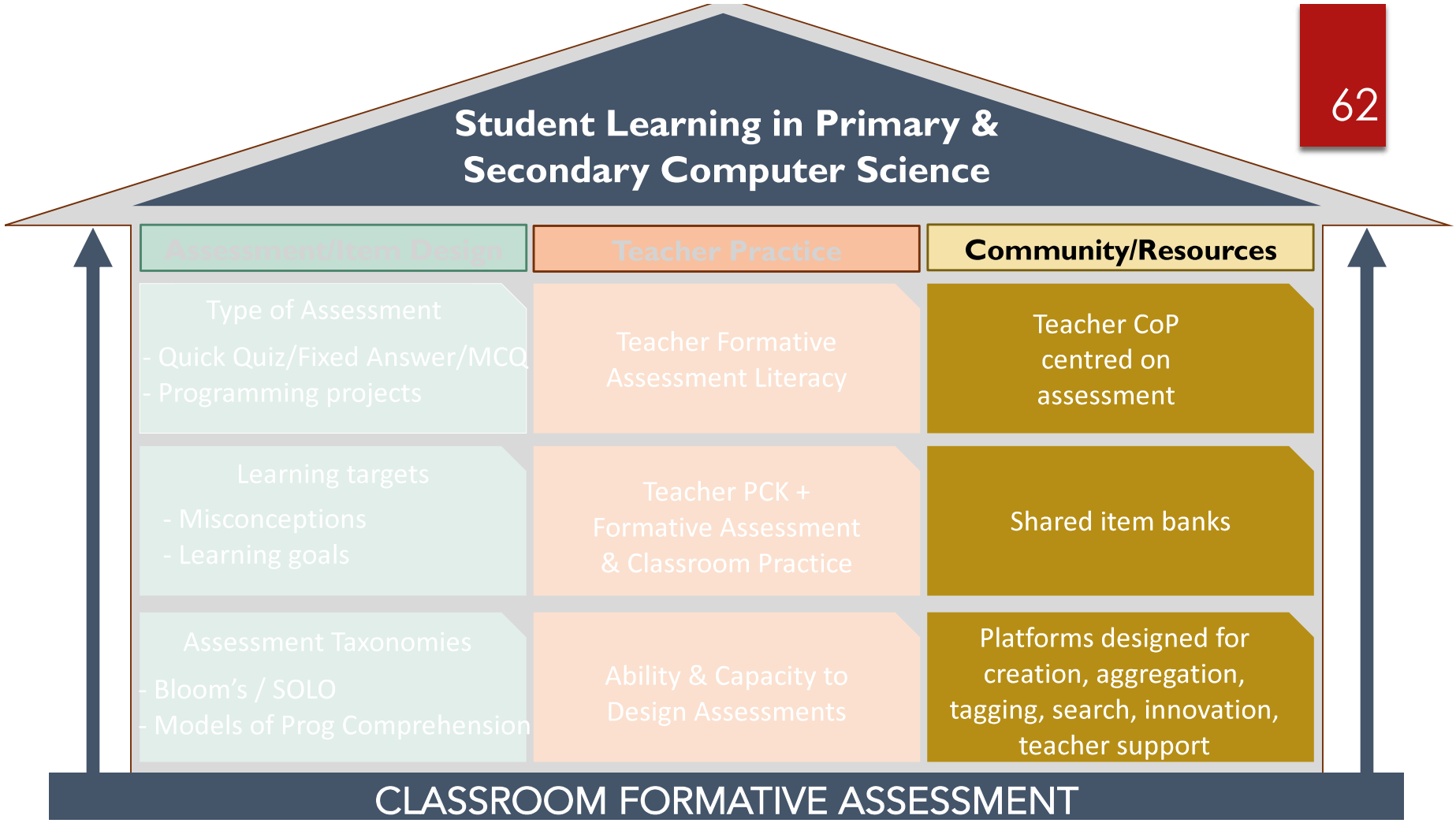
- Establish clear learning goals and success criteria
- Plan for and elicit evidence of learning during or in between lessons
- Interpret that evidence to judge where students are in relation to learning goals and success criteria
- Take pedagogical action based on the evidence
- Provide feedback to students to helping them understand
  - *Where am I going?*
  - *Where am I now?*
  - *What are my next steps?*
- Support students in peer- and self-assessment and reflection
- Foster a collaborative classroom culture where students and teachers are partners in learning

(Drawn from McManus, 2008; CCSSO, 2012; Heritage, 2013; & Jones et al., 2014)

# Actions by Schools & Administrators

- Demonstrating that they understand and value formative assessment, and when they do not, to take on a role as learners themselves
- Supporting teachers to learn about and have opportunities to experiment with aspects of formative assessment
- Providing and protecting time for teachers to engage in peer observations, meet in learning communities, and participate in other learning opportunities with peers outside of their teaching responsibilities
- Identifying and supporting teacher leaders to take on roles that extend beyond their classroom responsibilities
- Recognizing progress made by teachers at all stages of the learning continuum and celebrating their achievements[2]

(Heritage & Wylie, 2020)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- Models of Prog Comprehension
Ability & Capacity to Design Assessments
Platforms designed for creation, aggregation, tagging, search, innovation, teacher support
CLASSROOM FORMATIVE ASSESSMENT

# Community Efforts to Support Formative Assessment

- Teacher learning communities are a powerful mechanism to improve teachers' capabilities in using assessment in the service of learning
- A CoP sustains itself around a shared need, and the give and take of shared resources for all to benefit
- Item repositories are a useful mechanism but only when they are well-designed to support a CoP (Fincher, 2008)
  (e.g. Canterbury Item Bank, Edfinity, Project Quantum,…)

# Seeding an Assessments Hub and Catalyzing a Community of Educators for Student Success in CS (NSF Project #1943530)

1. Create a sustainable **assessments hub** created **for and by teachers** (along with researchers, curriculum developers, PD providers, and technologists)
    a. Organized by standards, grade, concepts, curriculum (AP CSP curricula and others), and other relevant criteria for intuitive use by teachers of all experience
    b. Push for rich, innovative assessments (that are auto-gradable) for quick formative feedback
    c. Target misconceptions & student difficulties

# Seeding an Assessments Hub and Catalyzing a Community of Educators for Student Success in CS (NSF Project #1943530)

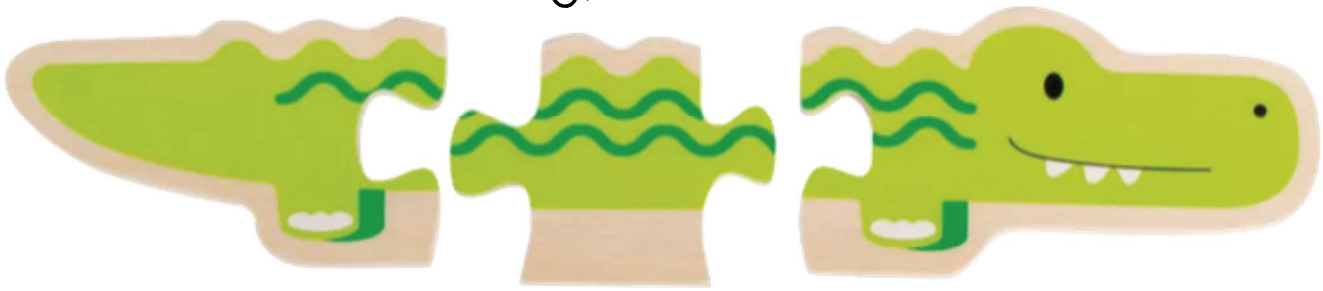
2. Build an 'Assessments **Community of Practice (CoP)**' of K-12 CS teachers through workshops & outreach activities.

a. Share /design/ discuss assessments

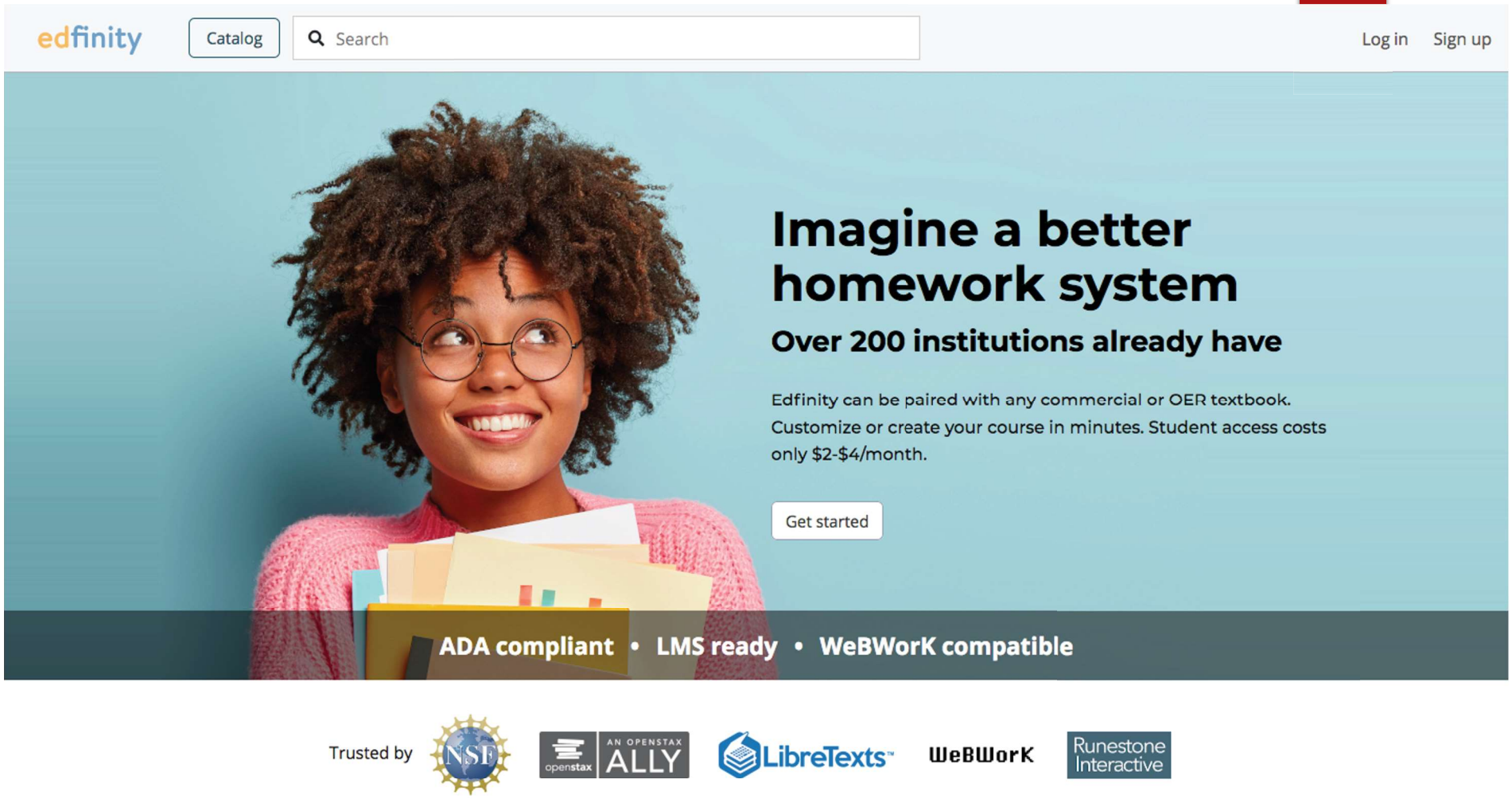
b. Build K-12 CS teachers' assessment capabilities (esp. formative classroom assessment)

# Seeding an Assessments Hub and Catalyzing a Community of Educators for Student Success in CS (NSF Project #1943530)

3. Research in classrooms on use of the formative assessments and its impact on teachers and teacher practice & examining effective assessment items (Pushed out due to Covid-19)

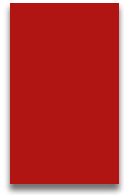


## Using Edfinity.com (an NSF-funded platform)

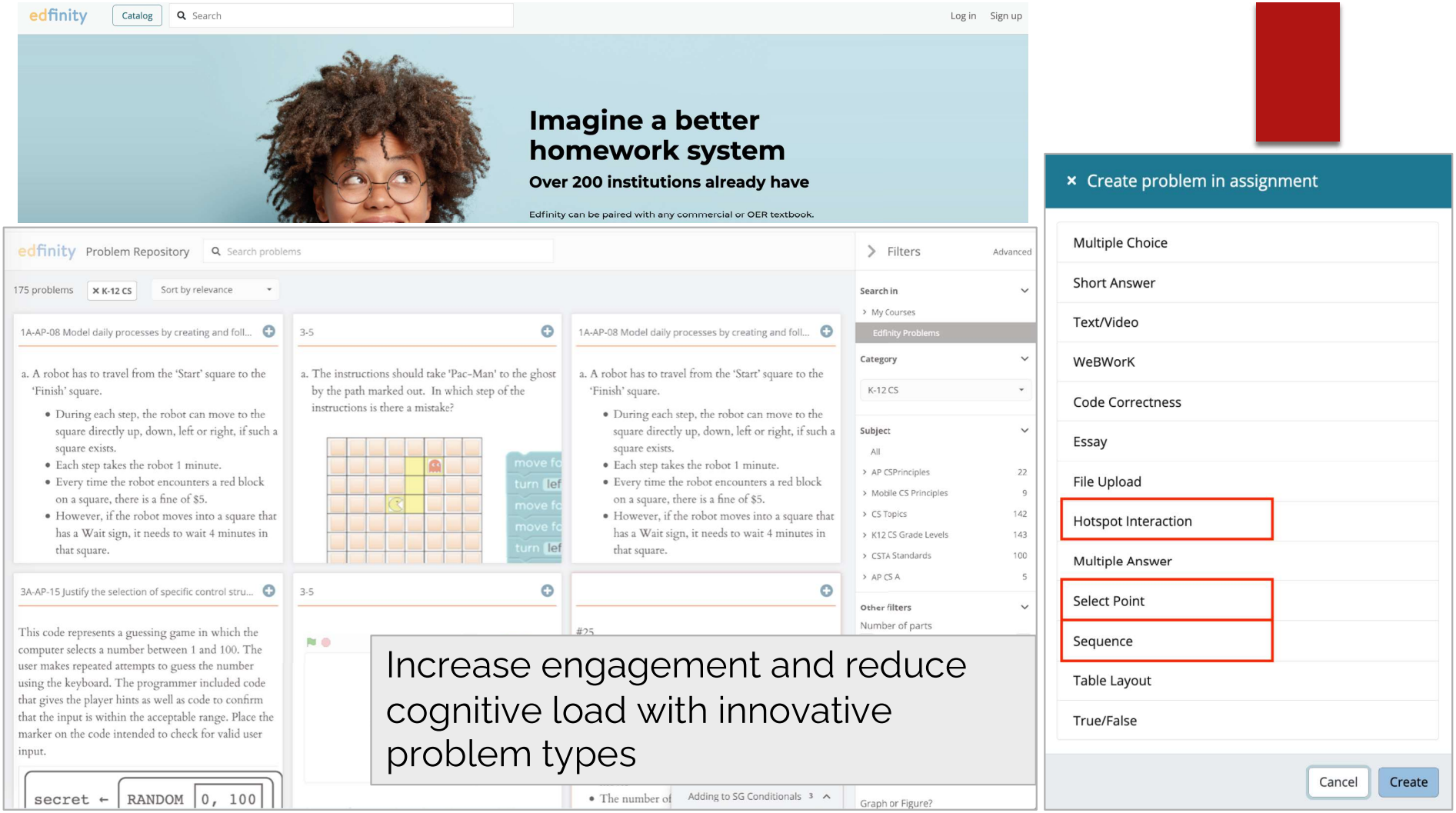


edfinity®

- **Autograding/randomization**
  - Multiple attempts
  - Solution explanation/feedback
- **Rich & Innovative problem types**
  - Parson's Problems
  - Hotspot/Point & Click
  - Code Correctness
  - Rich text (videos/embed code) in problem
- **Tag problems based on taxonomies or ad-hoc tags**
- **Repository with powerful search functionality**, and catalog of pre-built problem-sets



- **Supports teacher collaboration**
  - Share problemsets & quizzes (view/edit mode a la Google Docs)
- **Classroom setup**
  - Practice problems; tests; searchable repository
  - Dashboard with analytics
  - Use pre-built or create own problem sets with ease
- **ADA Compliant**


edfinity
Catalog
Search
Log in
Sign up
Imagine a better homework system
Over 200 institutions already have
Edfinity can be paired with any commercial or OER textbook.
edfinity Problem Repository
Search problems
Filters
Advanced
175 problems
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secret ← RANDOM 0, 100
Search in
My Courses
Edfinity Problems
Category
K-12 CS
Subject
All
AP CSPrinciples 22
Mobile CS Principles 9
CS Topics 142
K12 CS Grade Levels 143
CSTA Standards 100
AP CS A 5
Other filters
Number of parts
Graph or Figure?
Adding to SG Conditionals 3
Increase engagement and reduce cognitive load with innovative problem types
Create problem in assignment
Multiple Choice
Short Answer
Text/Video
WeBWorK
Code Correctness
Essay
File Upload
Hotspot Interaction
Multiple Answer
Select Point
Sequence
Table Layout
True/False
Cancel
Create

Run the Scratch program and select the option that shows the solution for this program.


Rich text (videos/embed code) in problem can increase engagement and reduce cognitive load and reliance on reading.

# CS Assessments Hub

**Taxonomies**

- CS Topics
- CSTA Standards
- Grade Band
- AP CS Principles
- AP CS A
- Mobile CSP
- …

**Leveraging existing assessments**

- Middle school Scratch
- Mobile CSP
- Code.org - CSD & CSP
- BJC
- AP CS A
- AP CS Principles release items
- FACT/VELA MS assessment
- CT-M assessment
- …

New Items Targeting Misconceptions

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# THANK YOU!

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