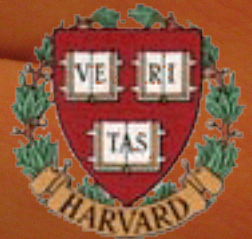ConcepTest design workshop
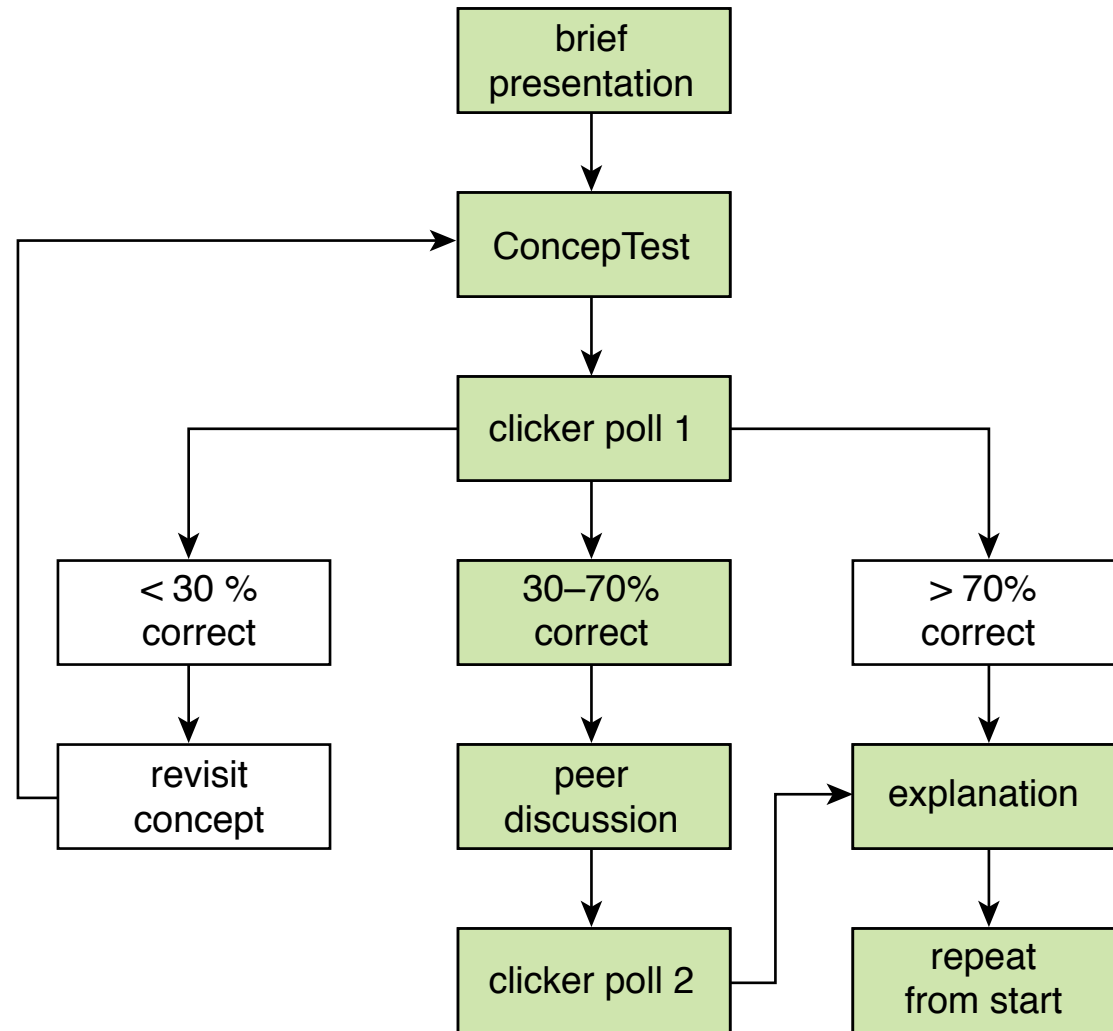
Seminario Internacional:
Metodologías Activas y Evaluación de Aprendizaje
Santiago, Chile, 19 de julio 2011
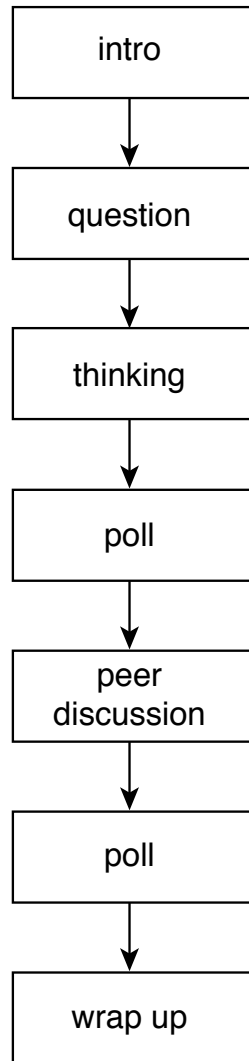
Outline

- **anatomy of a ConcepTest**

- **effective implementation**

- **creating ConcepTests**

Anatomy of a ConcepTest

Anatomy of a ConcepTest

```
┌─────────────────┐
│      intro      │
└────────┬────────┘
         ↓
┌─────────────────┐
│    question     │
└────────┬────────┘
         ↓
┌─────────────────┐
│    thinking     │
└────────┬────────┘
         ↓
┌─────────────────┐
│      poll       │
└────────┬────────┘
         ↓
┌─────────────────┐
│      peer       │
│   discussion    │
└────────┬────────┘
         ↓
┌─────────────────┐
│      poll       │
└────────┬────────┘
         ↓
┌─────────────────┐
│     wrap up     │
└─────────────────┘
```
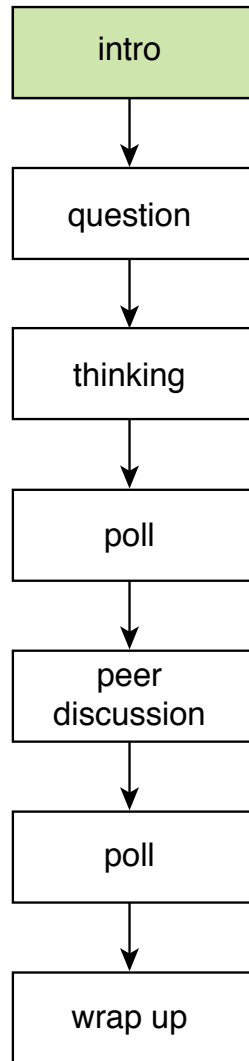
setting context

Anatomy of a ConcepTest

```
┌─────────────┐
│    intro    │
└─────────────┘
       │
       ▼
┌─────────────┐
│  question   │
└─────────────┘
       │
       ▼
┌─────────────┐
│  thinking   │
└─────────────┘
       │
       ▼
┌─────────────┐
│    poll     │
└─────────────┘
       │
       ▼
┌─────────────┐
│    peer     │
│ discussion  │
└─────────────┘
       │
       ▼
┌─────────────┐
│    poll     │
└─────────────┘
       │
       ▼
┌─────────────┐
│   wrap up   │
└─────────────┘
```
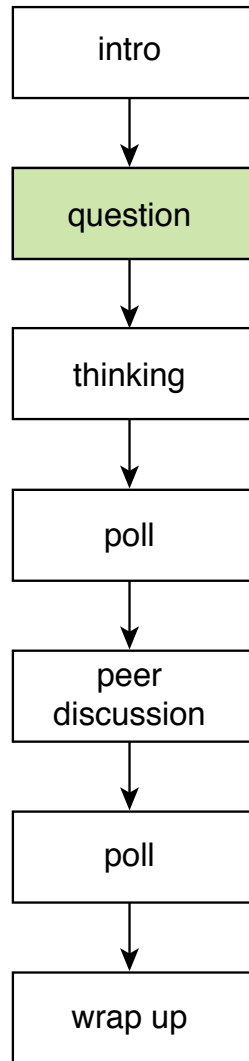
setting context

posing question

Anatomy of a ConcepTest

intro   **setting context**

question   **posing question**

thinking   **reflection**

poll

peer discussion

poll

wrap up

Anatomy of a ConcepTest

intro	setting context
↓	
question	posing question
↓	
thinking	reflection
↓	
poll	baseline data
↓	
peer discussion	
↓	
poll	
↓	
wrap up	

Anatomy of a ConcepTest

```
┌──────────────┐
│    intro     │        setting context
└──────────────┘
       │
       ▼
┌──────────────┐
│   question   │        posing question
└──────────────┘
       │
       ▼
┌──────────────┐
│   thinking   │        reflection
└──────────────┘
       │
       ▼
┌──────────────┐
│     poll     │        baseline data
└──────────────┘
       │
       ▼
┌──────────────┐
│     peer     │        peer instruction
│  discussion  │
└──────────────┘
       │
       ▼
┌──────────────┐
│     poll     │
└──────────────┘
       │
       ▼
┌──────────────┐
│   wrap up    │
└──────────────┘
```

Anatomy of a ConcepTest

intro → **setting context**

question → **posing question**

thinking → **reflection**

poll → **baseline data**

peer discussion → **peer instruction**

poll → **gain data**

wrap up

Anatomy of a ConcepTest

intro	**setting context**
question	**posing question**
thinking	**reflection**
poll	**baseline data**
peer discussion	**peer instruction**
poll	**gain data**
wrap up	**closure**

Anatomy of a ConcepTest
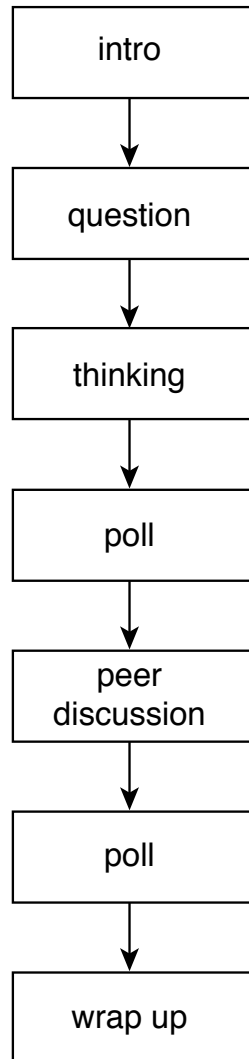
intro	setting context	5 min (max)
question	posing question	1 min
thinking	reflection	1–2 min
poll	baseline data	
peer discussion	peer instruction	2–3 min
poll	gain data	
wrap up	closure	5 min (max)

potential shortcuts

```
┌─────────────┐
│    intro    │
└─────────────┘
       │
       ▼
┌─────────────┐
│  question   │
└─────────────┘
       │
       ▼
┌─────────────┐
│  thinking   │
└─────────────┘
       │
       ▼
┌─────────────┐
│    poll     │
└─────────────┘
       │
       │
       ▼
┌─────────────┐
│   wrap up   │
└─────────────┘
```
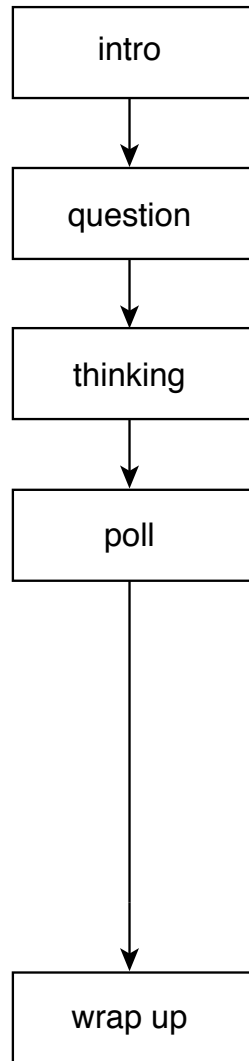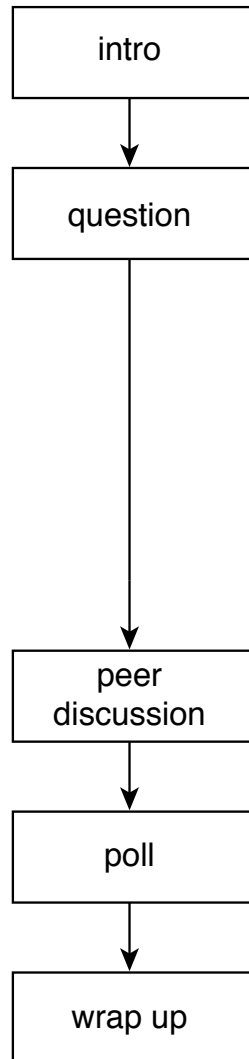
2–3 min saved, but…

takes the "Peer" out of "Peer Instruction"

Anatomy of a ConcepTest

potential shortcuts

```
┌──────────────┐
│    intro     │
└──────────────┘
        │
        ▼
┌──────────────┐
│   question   │
└──────────────┘
        │
        ▼
┌──────────────┐
│     peer     │
│  discussion  │
└──────────────┘
        │
        ▼
┌──────────────┐
│     poll     │
└──────────────┘
        │
        ▼
┌──────────────┐
│   wrap up    │
└──────────────┘
```

launch straight into discussion?

Let's try it!

projectile trajectories

Let's try it!

projectile trajectories
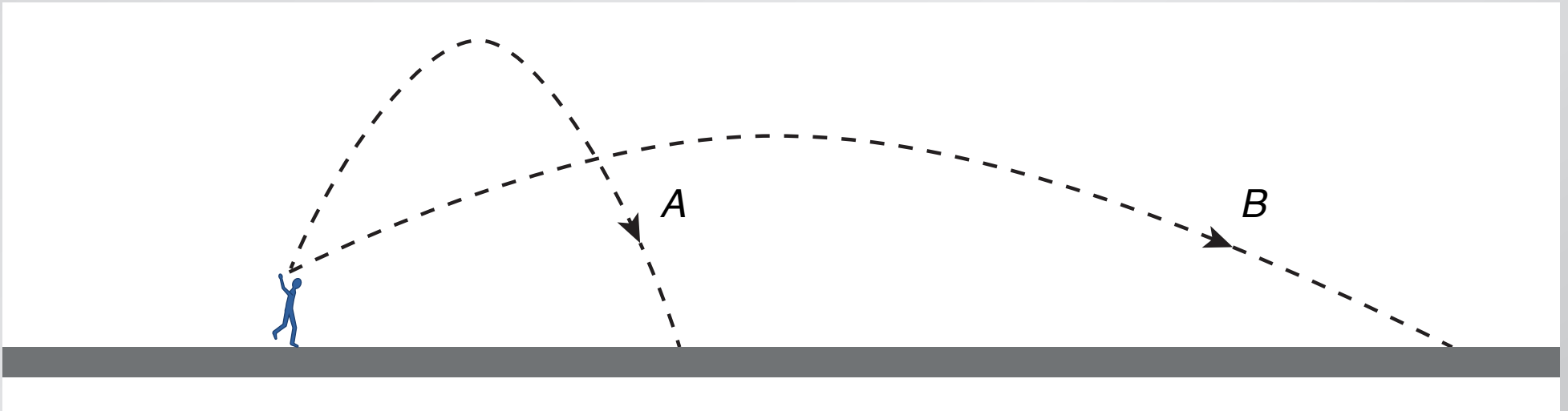
motion up = inverse of motion down

Let's try it!

projectile trajectories

motion up = inverse of motion down
horizontal/vertical motion decoupled

You simultaneously throw two coins. If the coins follow the parabolic trajectories shown below, which coin hits the ground first?
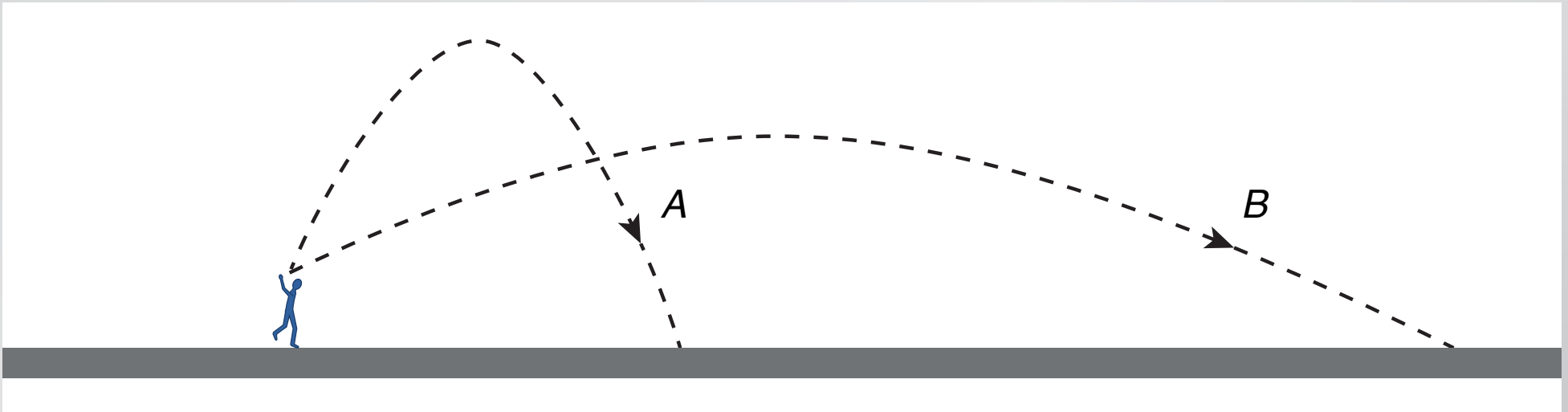
Let's try it!

You simultaneously throw two coins. If the coins follow the parabolic trajectories shown below, which coin hits the ground first?

1. A
2. both at (nearly) the same time
3. B
4. need more information

Let's try it!

time each coin spends in air
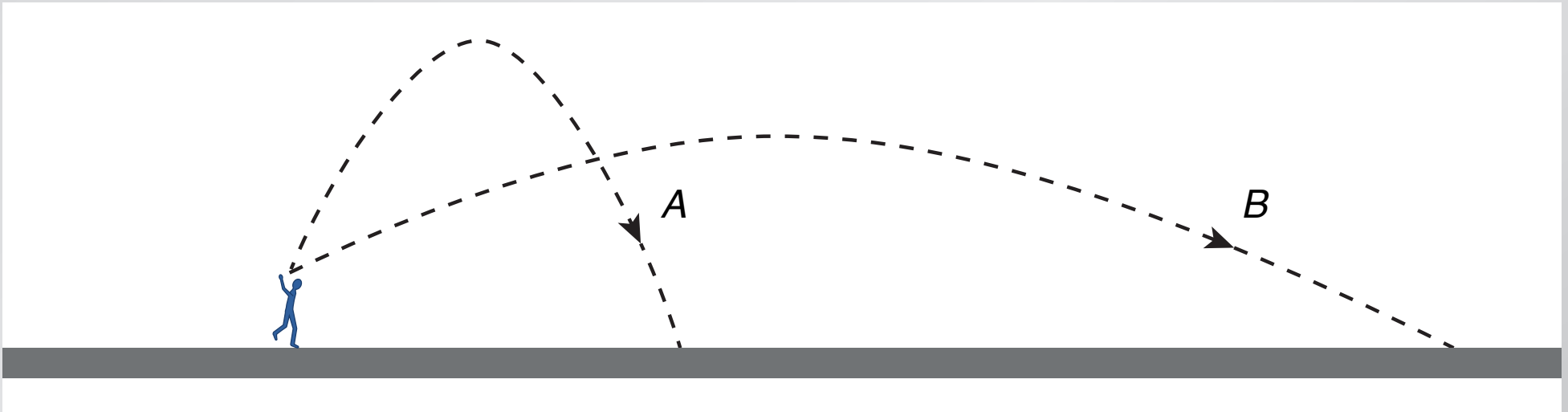
¡Vamos a intentarlo!

time each coin spends in air

$$2t_h$$

(twice the time it takes to fall from maximum height)

¡Vamos a intentarlo!

You simultaneously throw two coins. If the coins follow the parabolic trajectories shown below, which coin hits the ground first?

1. A
2. both at (nearly) the same time
3. B
4. need more information

potential shortcuts

```
┌──────────────┐
│    intro     │
└──────────────┘
       │
       ▼
┌──────────────┐
│   question   │
└──────────────┘
       │
       │
       ▼
┌──────────────┐
│     peer     │
│  discussion  │
└──────────────┘
       │
       ▼
┌──────────────┐
│     poll     │
└──────────────┘
       │
       ▼
┌──────────────┐
│   wrap up    │
└──────────────┘
```

1–2 min saved, but…

no opportunity to commit before discussion

potential shortcuts

```
┌──────────────┐
│    intro     │
└──────────────┘
        │
        ▼
┌──────────────┐
│   question   │
└──────────────┘
        │
        │
        ▼
┌──────────────┐
│     peer     │
│  discussion  │
└──────────────┘
        │
        ▼
┌──────────────┐
│     poll     │
└──────────────┘
        │
        ▼
┌──────────────┐
│   wrap up    │
└──────────────┘
```
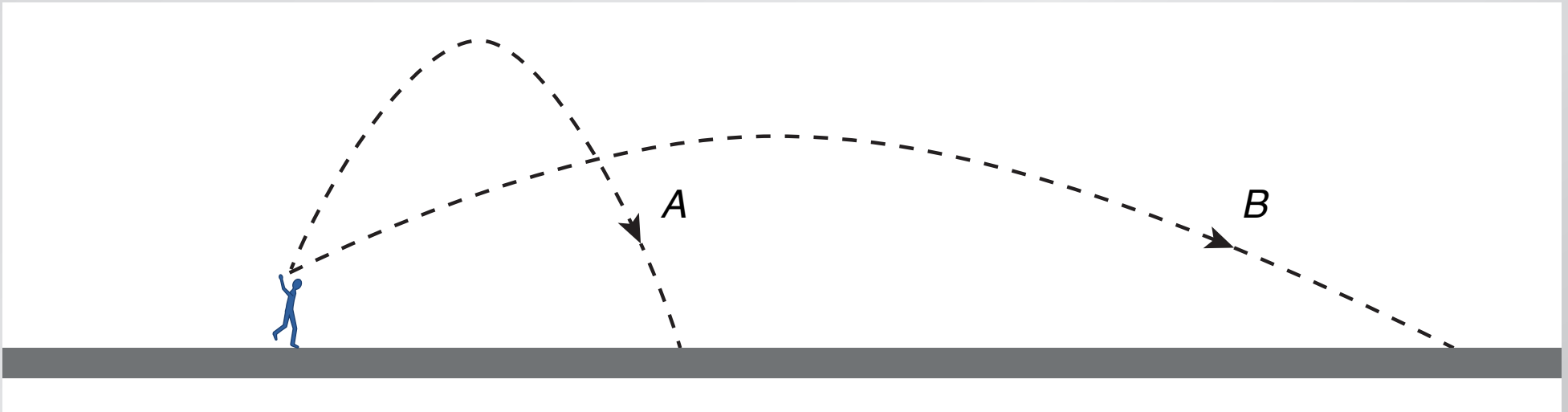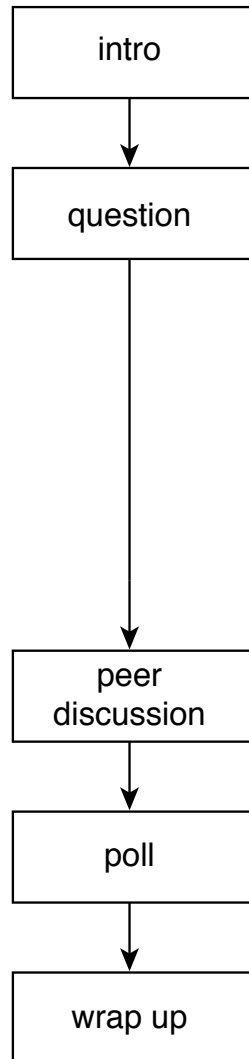
1–2 min saved, but…

no opportunity to commit before discussion

Boyle, *et. al*, Studies in Higher Education, 28, 4 (2003) 457

Anatomy of a ConcepTest

potential shortcuts

```
┌─────────────┐
│    intro    │
└─────────────┘
       │
       ▼
┌─────────────┐
│  question   │
└─────────────┘
       │
       │
       ▼
┌─────────────┐
│    peer     │
│ discussion  │
└─────────────┘
       │
       ▼
┌─────────────┐
│    poll     │
└─────────────┘
       │
       ▼
┌─────────────┐
│   wrap up   │
└─────────────┘
```
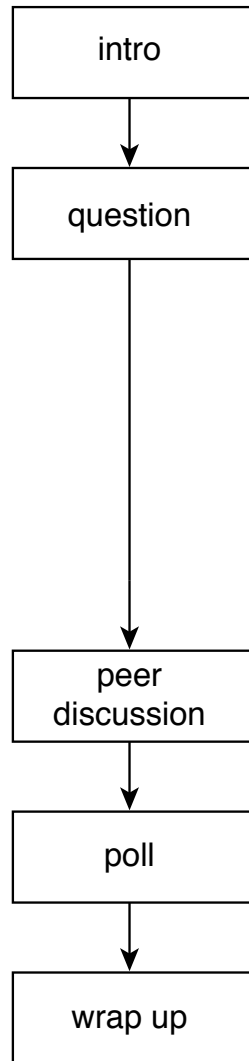
1–2 min saved, but…

no opportunity to commit before discussion

(and no information on effectiveness of CT!)

Anatomy of a ConcepTest

should count on about 15 min per ConcepTest

Anatomy of a ConcepTest

should count on about 15 min per ConcepTest

(including two pollings)

Outline

- anatomy of a ConcepTest

- effective implementation

- creating ConcepTests

engendering "deep learning"

```
┌──────────────┐
│     intro    │
└──────┬───────┘
       ↓
┌──────────────┐
│   question   │
└──────┬───────┘
       ↓
┌──────────────┐
│   thinking   │
└──────┬───────┘
       ↓
┌──────────────┐
│     poll     │
└──────┬───────┘
       ↓
┌──────────────┐
│     peer     │
│  discussion  │
└──────┬───────┘
       ↓
┌──────────────┐
│     poll     │
└──────┬───────┘
       ↓
┌──────────────┐
│    wrap up   │
└──────────────┘
```

Effective implementation

engendering "deep learning"

```
┌──────────────┐
│    intro     │
└──────┬───────┘
       ↓
┌──────────────┐
│   question   │
└──────┬───────┘
       ↓
┌──────────────┐
│   thinking   │
└──────┬───────┘
       ↓
┌──────────────┐
│     poll     │
└──────┬───────┘
       ↓
┌──────────────┐
│     peer     │
│  discussion  │
└──────┬───────┘
       ↓
┌──────────────┐
│     poll     │
└──────┬───────┘
       ↓
┌──────────────┐
│   wrap up    │
└──────────────┘
```

Effective implementation

```
┌──────────────────┐
│      intro       │
└──────────────────┘
         │
         ▼
┌──────────────────┐
│    question      │
└──────────────────┘
         │
         ▼
┌──────────────────┐
│    thinking      │
└──────────────────┘
         │
         ▼
┌──────────────────┐
│      poll        │
└──────────────────┘
         │
         ▼
┌──────────────────┐
│      peer        │
│   discussion     │
└──────────────────┘
         │
         ▼
┌──────────────────┐
│      poll        │
└──────────────────┘
         │
         ▼
┌──────────────────┐
│     wrap up      │
└──────────────────┘
```
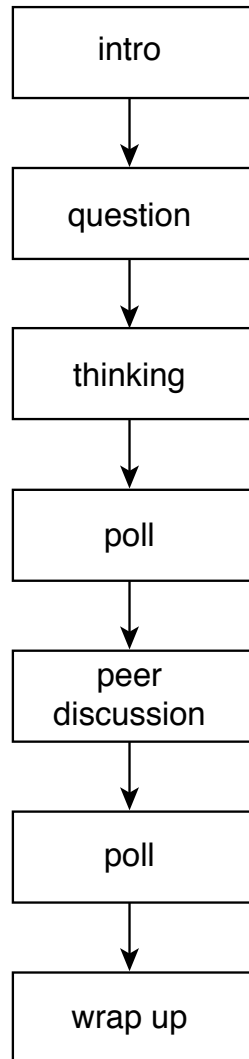
engendering "deep learning"

pre-class activity determines context

Effective implementation

engendering "deep learning"

```
┌──────────────┐
│    intro     │
└──────────────┘
       │
       ▼
┌──────────────┐
│   question   │
└──────────────┘
       │
       ▼
┌──────────────┐
│   thinking   │
└──────────────┘
       │
       ▼
┌──────────────┐
│     poll     │
└──────────────┘
       │
       ▼
┌──────────────┐
│     peer     │
│  discussion  │
└──────────────┘
       │
       ▼
┌──────────────┐
│     poll     │
└──────────────┘
       │
       ▼
┌──────────────┐
│   wrap up    │
└──────────────┘
```
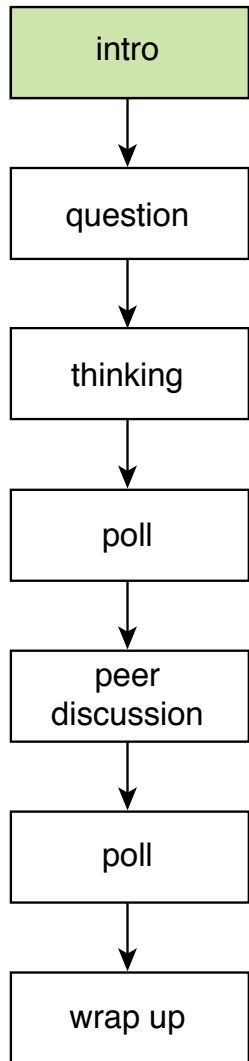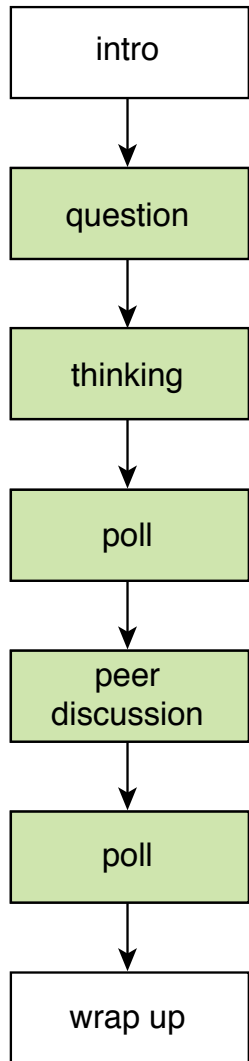
question transfers concepts to new context

engendering "deep learning"

intro
↓
question
↓
thinking
↓
poll
↓
peer discussion
↓
poll
↓
wrap up
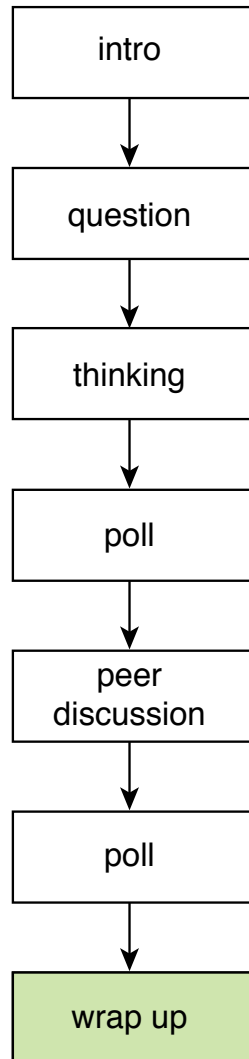
provide *your* explanation

Effective implementation

importance of peer discussion

```
┌──────────────┐
│    intro     │
└──────────────┘
        │
        ▼
┌──────────────┐
│   question   │
└──────────────┘
        │
        ▼
┌──────────────┐
│   thinking   │
└──────────────┘
        │
        ▼
┌──────────────┐
│     poll     │
└──────────────┘
        │
        ▼
┌──────────────┐
│     peer     │
│  discussion  │
└──────────────┘
        │
        ▼
┌──────────────┐
│     poll     │
└──────────────┘
        │
        ▼
┌──────────────┐
│   wrap up    │
└──────────────┘
```

Effective implementation

importance of peer discussion

```
┌─────────┐
│  intro  │
└────┬────┘
     ▼
┌─────────┐
│ question│
└────┬────┘
     ▼
┌─────────┐
│ thinking│
└────┬────┘
     ▼
┌─────────┐
│  poll   │
└────┬────┘
     ▼
┌─────────┐
│  peer   │
│discussion│
└────┬────┘
     ▼
┌─────────┐
│  poll   │
└────┬────┘
     ▼
┌─────────┐
│ wrap up │
└─────────┘
```
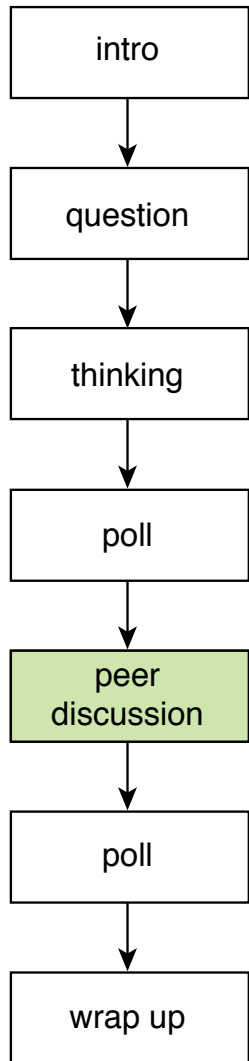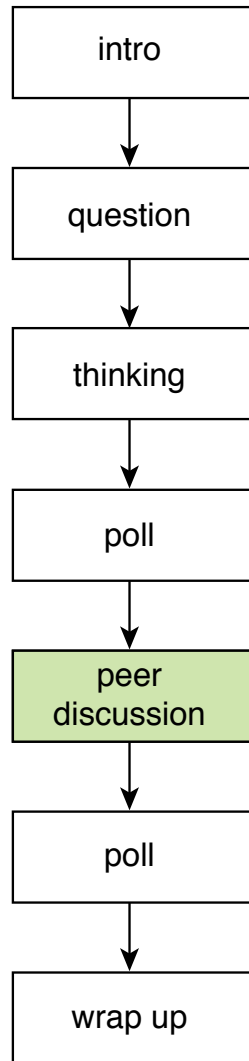
vary activity

Effective implementation

importance of peer discussion

```
  ┌─────────────┐
  │    intro    │
  └──────┬──────┘
         ↓
  ┌─────────────┐
  │  question   │
  └──────┬──────┘
         ↓
  ┌─────────────┐
  │  thinking   │
  └──────┬──────┘
         ↓
  ┌─────────────┐
  │    poll     │
  └──────┬──────┘
         ↓
  ┌─────────────┐
  │    peer     │
  │ discussion  │
  └──────┬──────┘
         ↓
  ┌─────────────┐
  │    poll     │
  └──────┬──────┘
         ↓
  ┌─────────────┐
  │   wrap up   │
  └─────────────┘
```
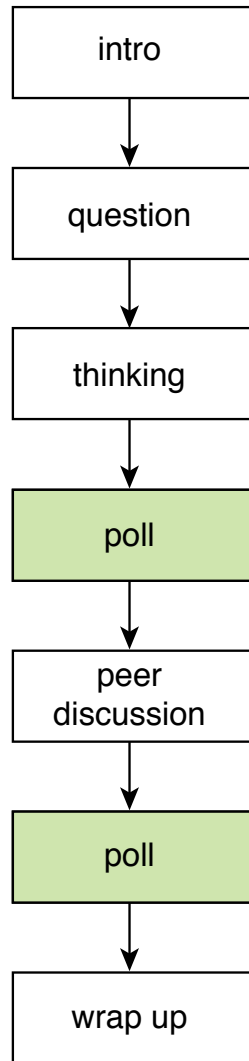
vary activity, measure poll-repoll gain

Effective implementation

importance of peer discussion

compare poll-repoll gain for 3 activities:
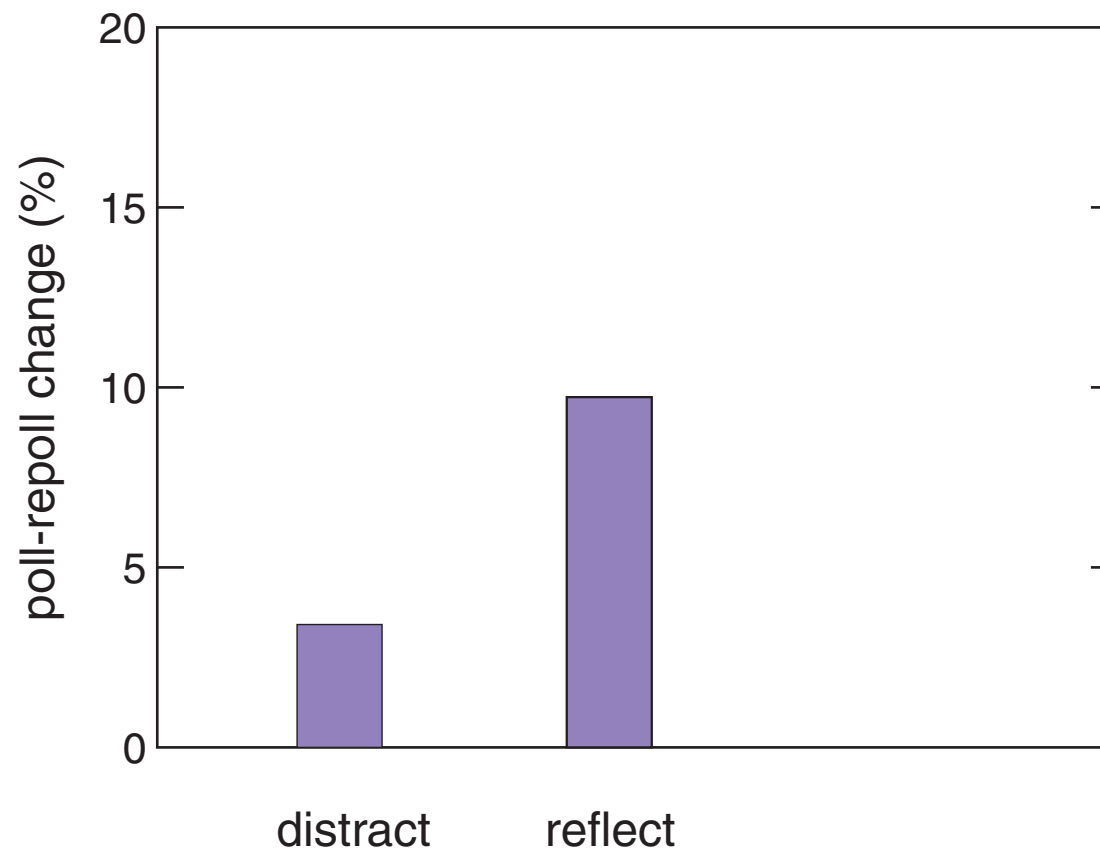
- **distract**

- **reflect**

- **discuss**

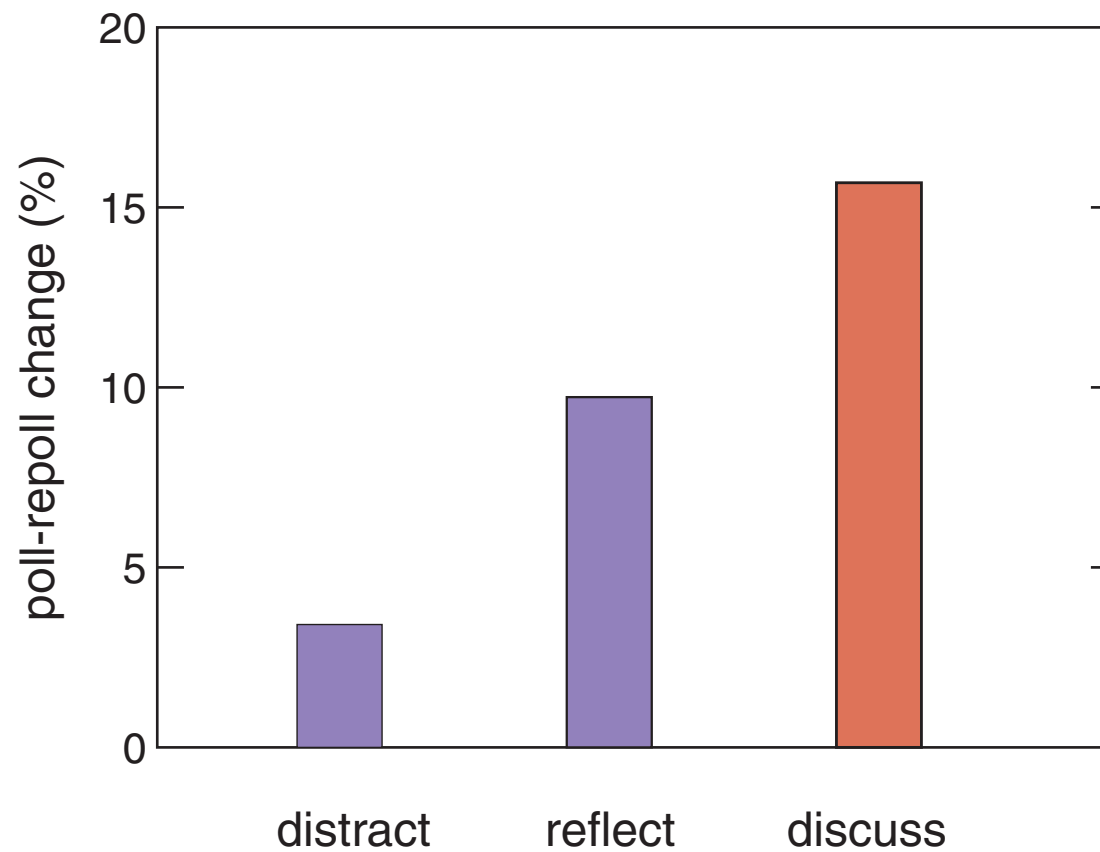# Effective implementation
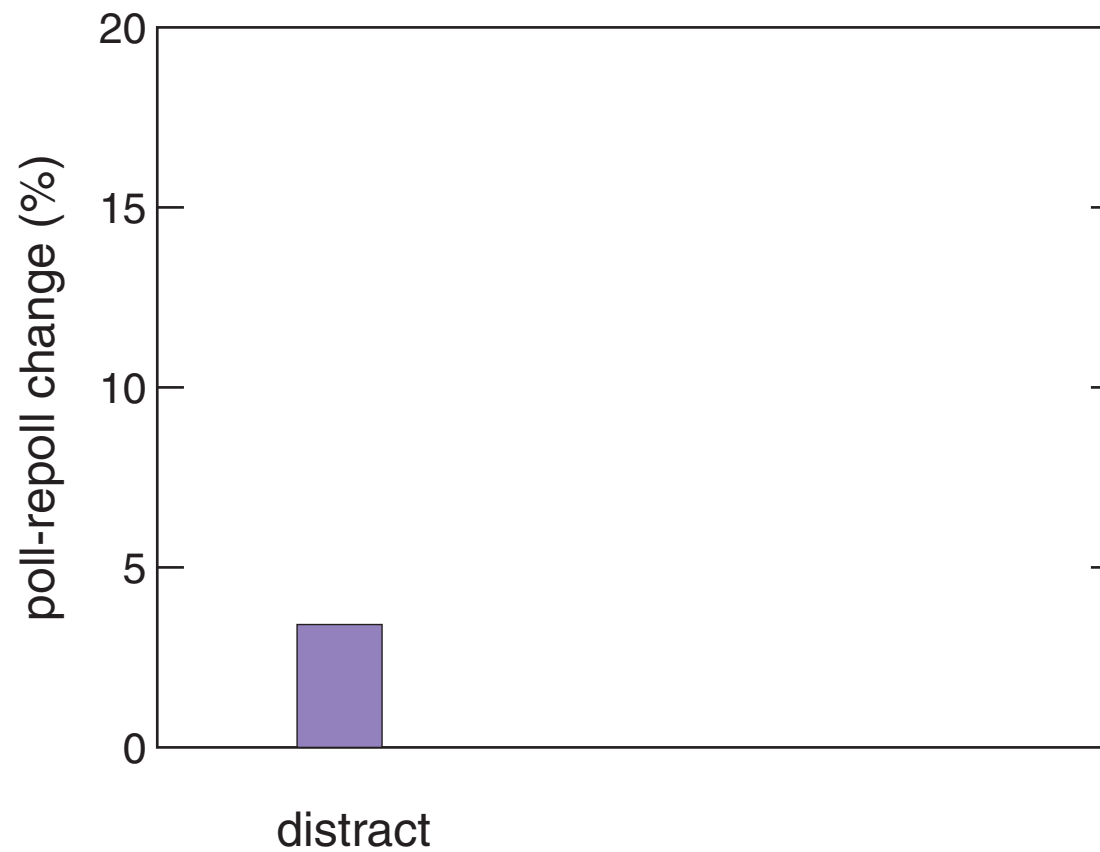
importance of peer discussion

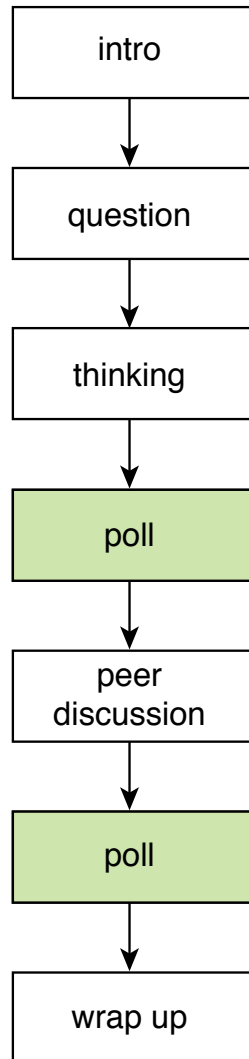# Effective implementation

importance of peer discussion

Effective implementation
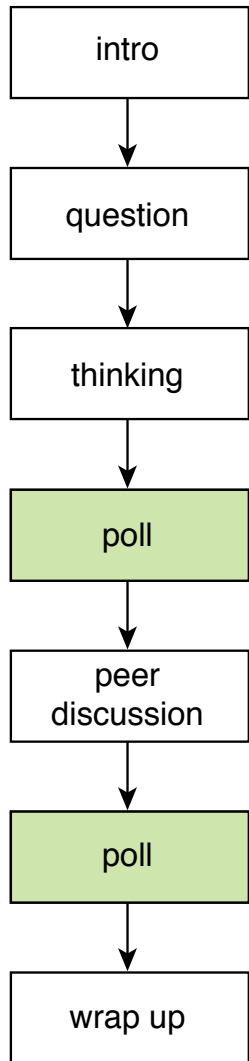
importance of peer discussion

Effective implementation

technology important?

```
┌──────────────┐
│    intro     │
└──────┬───────┘
       ↓
┌──────────────┐
│   question   │
└──────┬───────┘
       ↓
┌──────────────┐
│   thinking   │
└──────┬───────┘
       ↓
┌──────────────┐
│     poll     │
└──────┬───────┘
       ↓
┌──────────────┐
│     peer     │
│  discussion  │
└──────┬───────┘
       ↓
┌──────────────┐
│     poll     │
└──────┬───────┘
       ↓
┌──────────────┐
│   wrap up    │
└──────────────┘
```

Effective implementation

technology important?

normalized FCI gain:
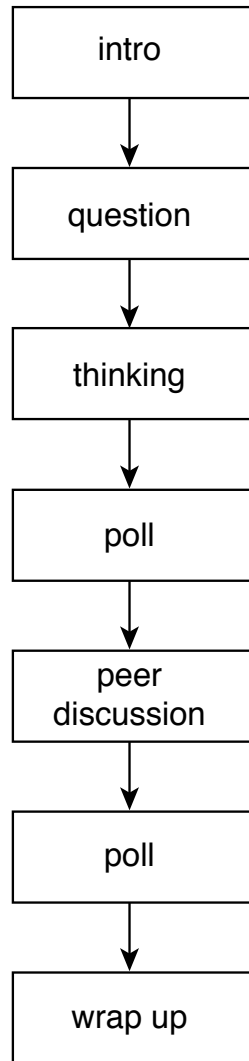
flashcards: 0.47

clickers: 0.44

Effective implementation

show histograms?

Effective implementation

show histograms?

```
┌──────────────┐
│    intro     │
└──────┬───────┘
       ↓
┌──────────────┐
│   question   │
└──────┬───────┘
       ↓
┌──────────────┐
│   thinking   │
└──────┬───────┘
       ↓
┌──────────────┐
│     poll     │
└──────┬───────┘
       ↓
┌──────────────┐
│     peer     │
│  discussion  │
└──────┬───────┘
       ↓
┌──────────────┐
│     poll     │
└──────┬───────┘
       ↓
┌──────────────┐
│   wrap up    │
└──────────────┘
```
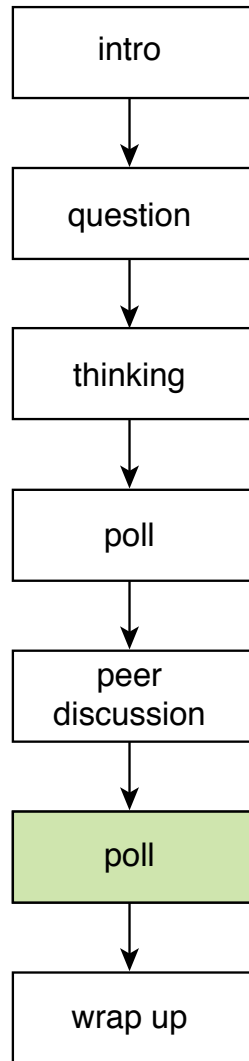
no — biases discussion

Effective implementation

show histograms?

```
┌─────────────┐
│    intro    │
└─────────────┘
       │
       ▼
┌─────────────┐
│  question   │
└─────────────┘
       │
       ▼
┌─────────────┐
│  thinking   │
└─────────────┘
       │
       ▼
┌─────────────┐
│    poll     │
└─────────────┘
       │
       ▼
┌─────────────┐
│    peer     │
│ discussion  │
└─────────────┘
       │
       ▼
┌─────────────┐
│    poll      │
└─────────────┘
       │
       ▼
┌─────────────┐
│   wrap up   │
└─────────────┘
```
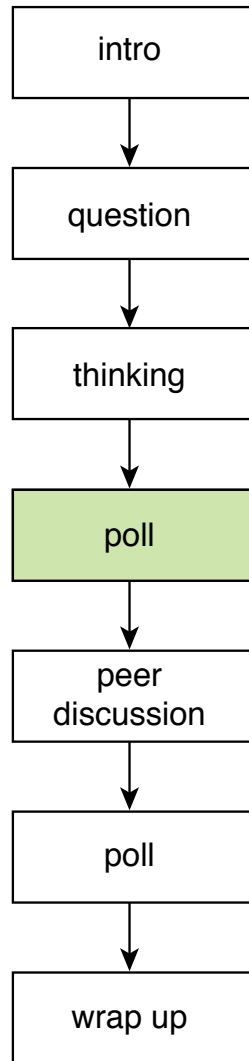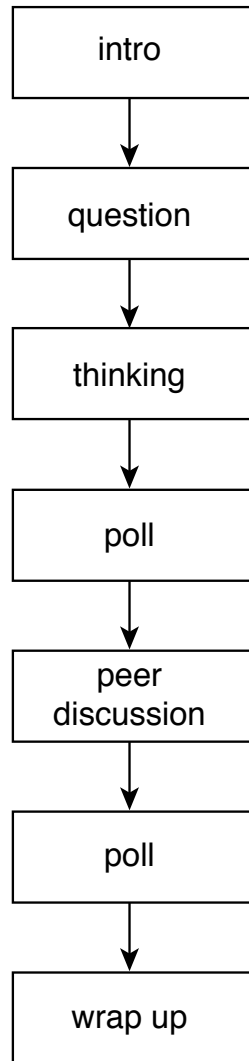
no — biases discussion

yes — helps bring closure

Effective implementation
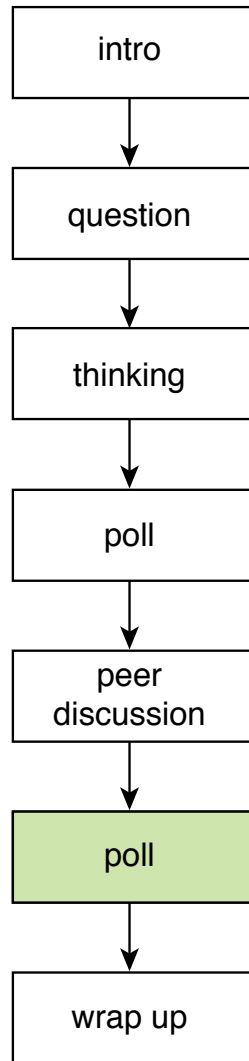
have individual students defend choices?


```
intro
  │
  ▼
question
  │
  ▼
thinking
  │
  ▼
poll
  │
  ▼
peer
discussion
  │
  ▼
poll
  │
  ▼
wrap up
```

Effective implementation

have individual students defend choices?

```
┌─────────────┐
│    intro    │
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┌─────────────┐
│  question   │
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│    poll     │
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│    peer     │
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┌─────────────┐
│    poll     │
└─────────────┘
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┌─────────────┐
│   wrap up   │
└─────────────┘
```
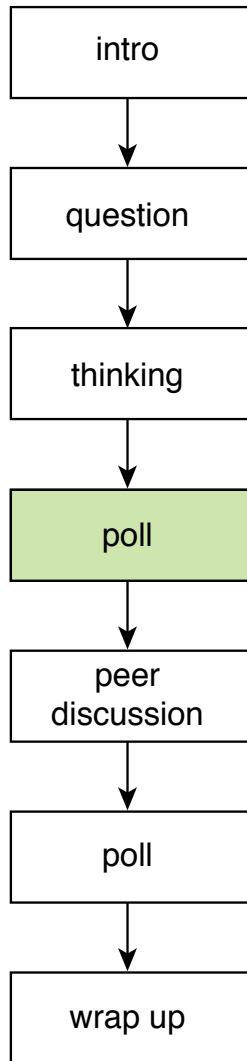
provides additional insights for discussion

Effective implementation

have individual students defend choices?

```
┌──────────┐
│   intro   │
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      │
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┌──────────┐
│ question  │
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┌──────────┐
│   poll    │
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┌──────────┐
│  wrap up  │
└──────────┘
```

involves students in wrap up

Outline

- anatomy of a ConcepTest

- effective implementation

- creating ConcepTests

```
┌──────────┐
│  intro   │
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     │
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┌──────────┐
│ question │
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│   peer   │
│discussion│
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┌──────────┐
│ wrap up  │
└──────────┘
```
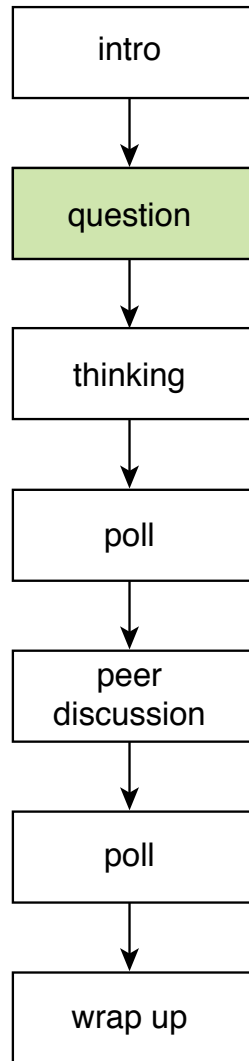
what constitutes an effective ConcepTest?

Creating ConcepTests
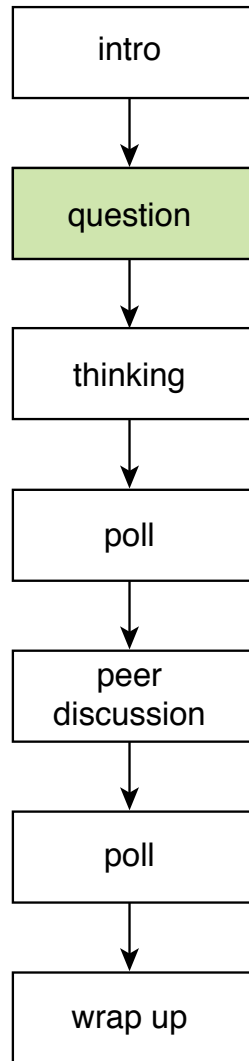
An effective ConcepTest…

- **is driven by student needs**

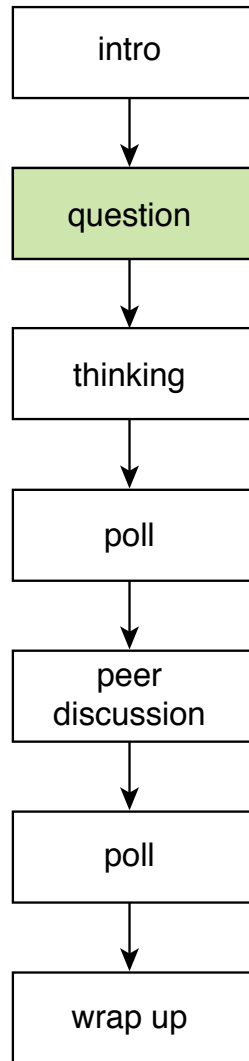- **tests understanding, not memorization**

- **pushes students (but not too much)**

Creating ConcepTests

```
┌─────────────────┐
│      intro      │
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┌─────────────────┐
│    question     │
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│    thinking     │
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│      poll       │
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│      peer       │
│   discussion    │
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┌─────────────────┐
│      poll       │
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┌─────────────────┐
│     wrap up     │
└─────────────────┘
```
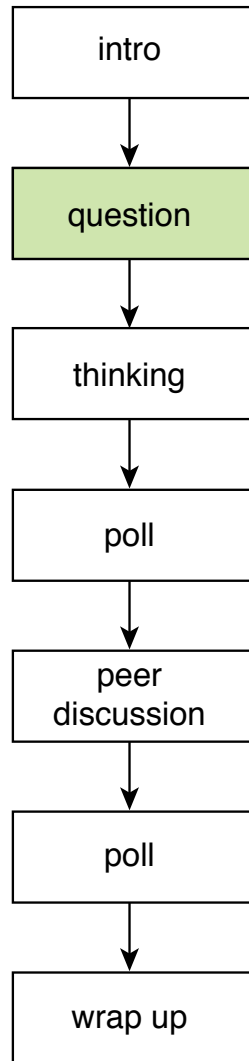
Sources of ConcepTests:

• **literature/web (you'd be surprised!)**

• **pre-class assignments**

• **other assignments**

Creating ConcepTests

```
┌───────────┐
│   intro   │
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│ question  │
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│   peer    │
│discussion │
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│   poll    │
└───────────┘
      │
      ▼
┌───────────┐
│  wrap up  │
└───────────┘
```

You can start with free response questions!

Creating ConcepTests

free-response ConcepTest
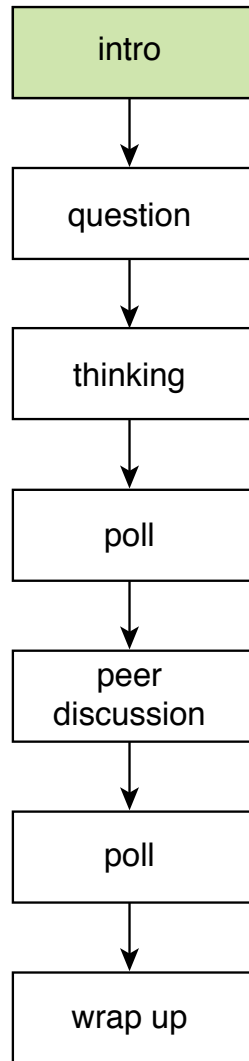
Electric field line patterns of a positively charged particle (right) and a negatively charged particle (left)
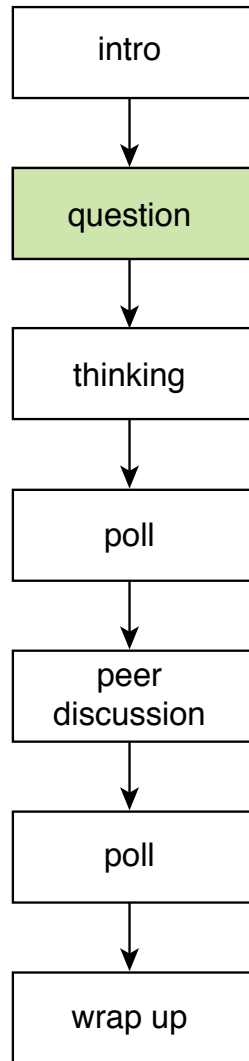
Creating ConcepTests

free-response ConcepTest

intro

question

thinking

poll

peer
discussion

poll

wrap up
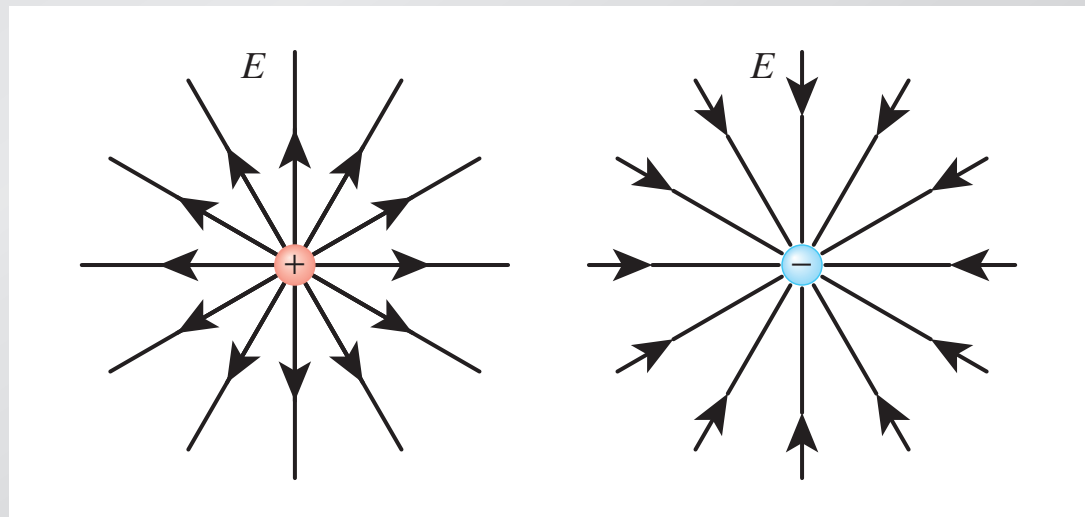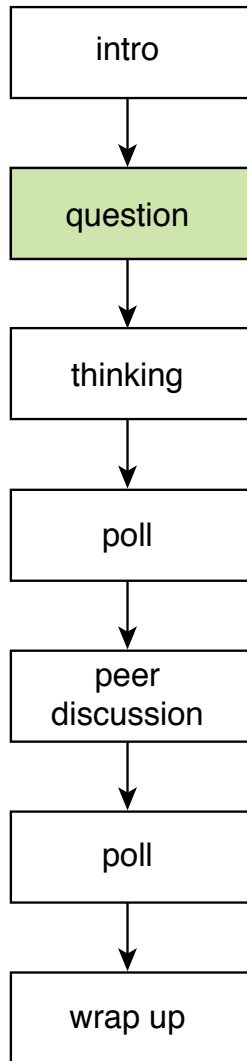
A dipole is placed as illustrated.
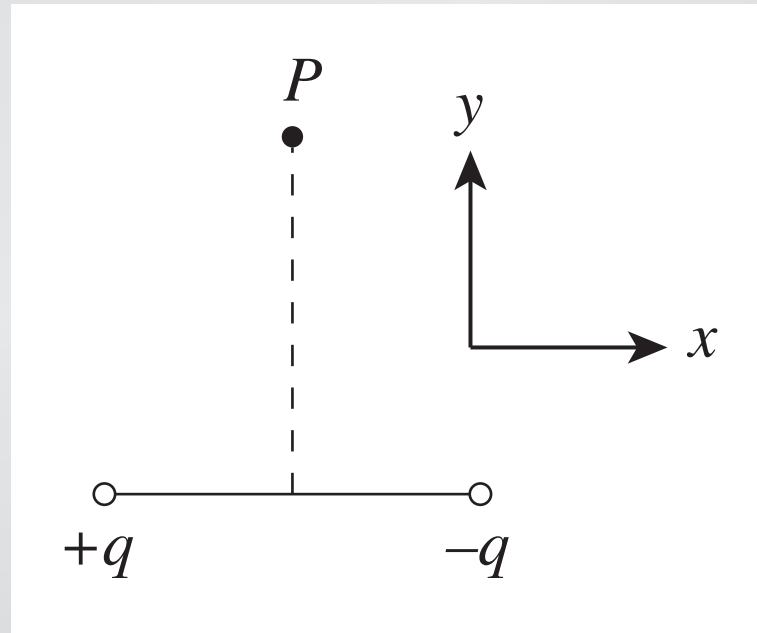
In which direction is the electric field at *P*?

(If it is zero, indicate so)
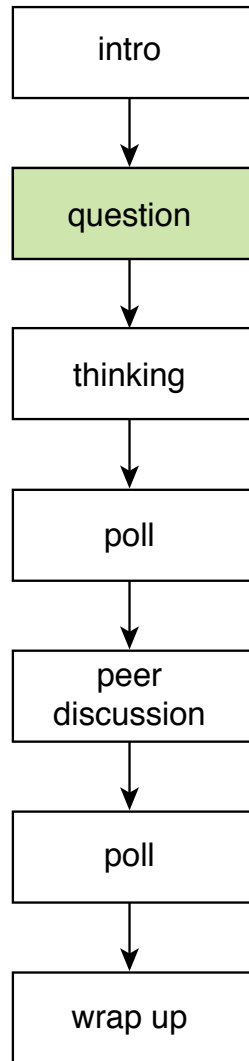
Creating ConcepTests

some basic design rules

intro → question → thinking → poll → peer discussion → poll → wrap up

Remove:

• **barriers for knowledgeable students**

• **clues for less-knowledgeable students**
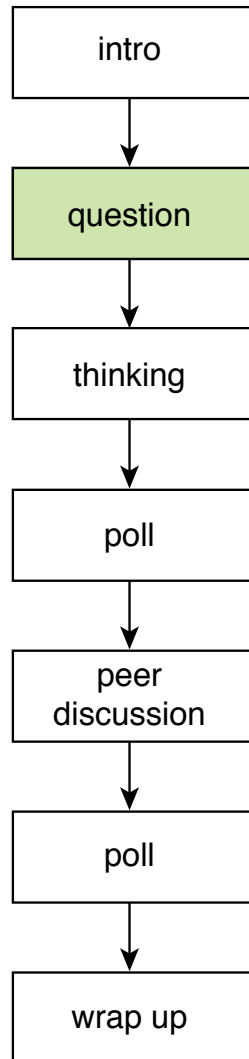
Creating ConcepTests

some basic design rules

```
┌──────────────┐
│    intro     │
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│   question   │
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│   thinking   │
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│     poll     │
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│     poll     │
└──────────────┘
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┌──────────────┐
│   wrap up    │
└──────────────┘
```

General tips:

- **focus on one idea/concept/model**

- **keep questions concise**

- **define all terms**

- **keep vocabulary simple**
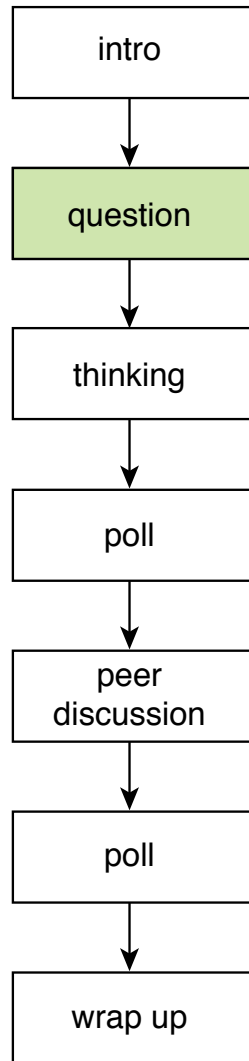
Creating ConcepTests

some basic design rules

```
┌─────────────┐
│    intro    │
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│  question   │
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│    poll     │
└─────────────┘
       │
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┌─────────────┐
│   wrap up   │
└─────────────┘
```

Writing good "stems":

- **ask complete question**

- **avoid common knowledge**

- **avoid negative statements ("not", "no",…)**

Creating ConcepTests

some basic design rules

```
┌──────────────┐
│     intro    │
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│   question   │
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│     poll     │
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┌──────────────┐
│   wrap up    │
└──────────────┘
```
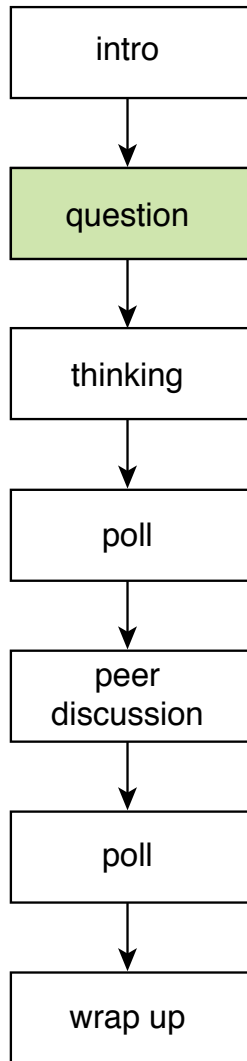
Writing good answer choices:

- **aim for 3–5 options**

- **order choices logically**

- **make all roughly same length**

- **avoid repeating words (move to stem)**

- **avoid "All/None of the above", "Other"**

Creating ConcepTests

Example: a nonsense question

intro → question → thinking → poll → peer discussion → poll → wrap up

Choose most likely correct answer, based on what you know about informed guessing on tests.

Under what circumstances do *ermazoa* coagulate?

A. Only when *jushespora* increase.

B. Only when *jushespora* change color.

C. When *jushespora* draw into a circle.

D. Usually when *jushespora* increase, but occasionally when *jushespora* decrease.

Creating ConcepTests

Example: another nonsense question

```
    intro
      |
      v
  question
      |
      v
  thinking
      |
      v
    poll
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      v
     peer
  discussion
      |
      v
    poll
      |
      v
   wrap up
```
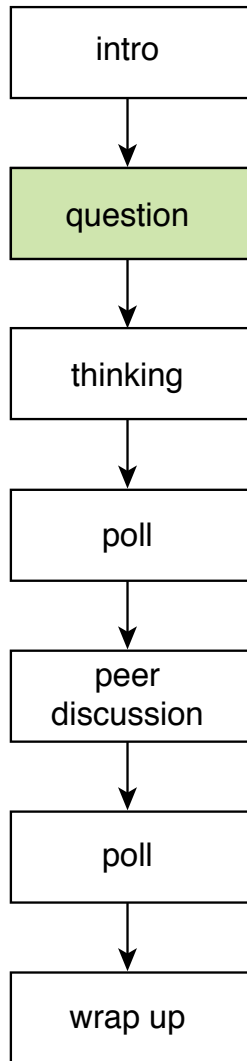
What is the color of *ermazoa*?

A. Blue.

B. Red.

C. Green.

D. Yellow.

Creating ConcepTests

Example: a well-crafted question

Which statement refers to measurement as opposed to evaluation?

A. Emily got 90% correct on her math quiz.

B. Mary's test scores have increased satisfac-torily this year.

C. Paul's score of 20 on this test indicates that his study habits are ineffective.
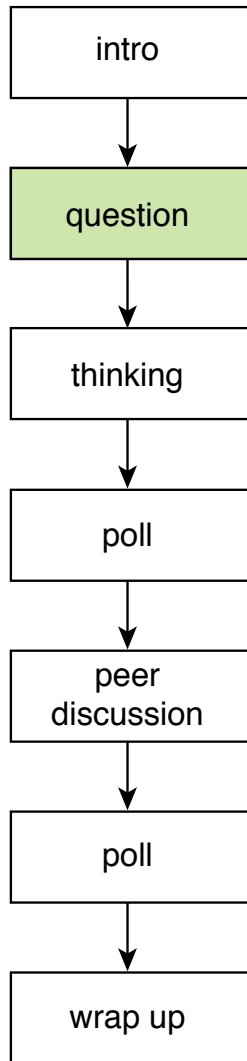
D. Linda received a B+ for her art project.

some of your questions

```
┌──────────────┐
│    intro     │
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┌──────────────┐
│   question   │
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│     peer     │
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┌──────────────┐
│     poll     │
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┌──────────────┐
│   wrap up    │
└──────────────┘
```

***

Creating ConcepTests

before trying out YOUR ConcepTests, need…

intro
↓
question
↓
thinking
↓
poll
↓
peer discussion
↓
poll
↓
wrap up

1. context

2. question

3. closure

When metals heat up, they expand because all atoms get farther away from each other.
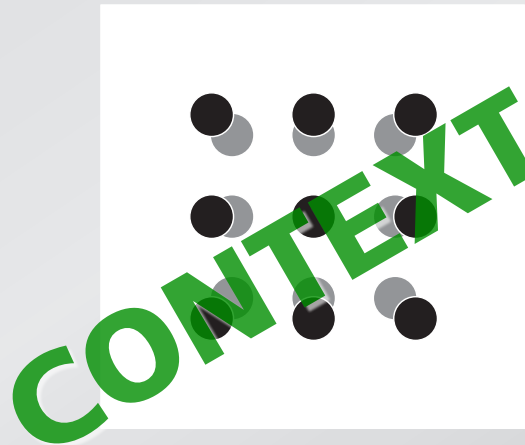
Consider a rectangular metal plate with a circular hole in it.
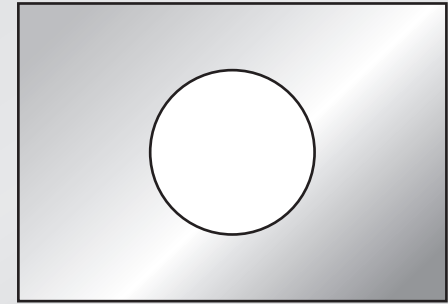
When the plate is uniformly heated, the diameter of the hole

1. increases.
2. stays the same.
3. decreases.

QUESTION

consider the atoms at the rim of the hole

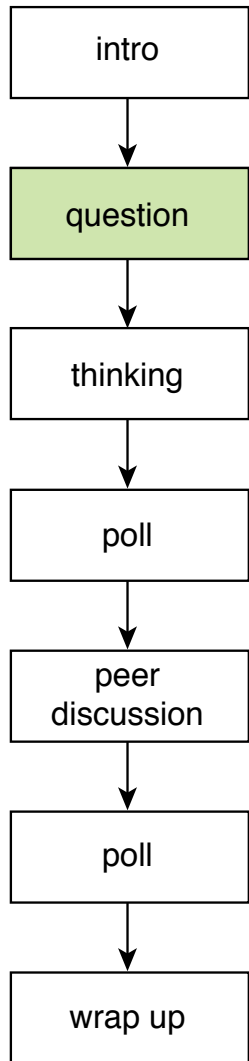# Creating ConcepTests

before trying out YOUR ConcepTests, need…

```
┌─────────────┐
│    intro    │
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       ▼
┌─────────────┐
│  question   │
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┌─────────────┐
│   thinking  │
└──────┬──────┘
       ▼
┌─────────────┐
│    poll     │
└──────┬──────┘
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┌─────────────┐
│     peer    │
│  discussion │
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┌─────────────┐
│    poll     │
└──────┬──────┘
       ▼
┌─────────────┐
│   wrap up   │
└─────────────┘
```

1. context

2. question

3. closure
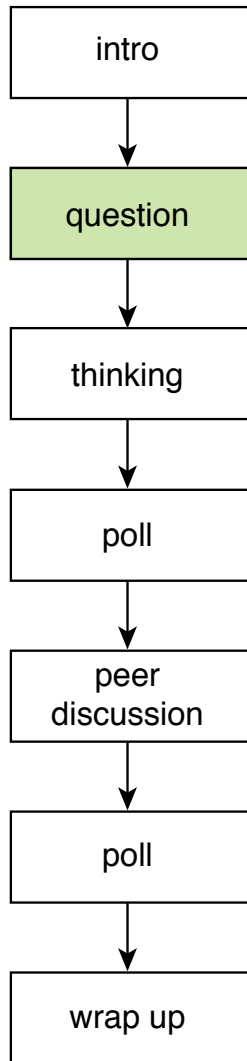
Creating ConcepTests

let's get started: topic selection

1. Think of some basic mistake your students make

2. Test idea out at your table (free-response)

3. Record answers given
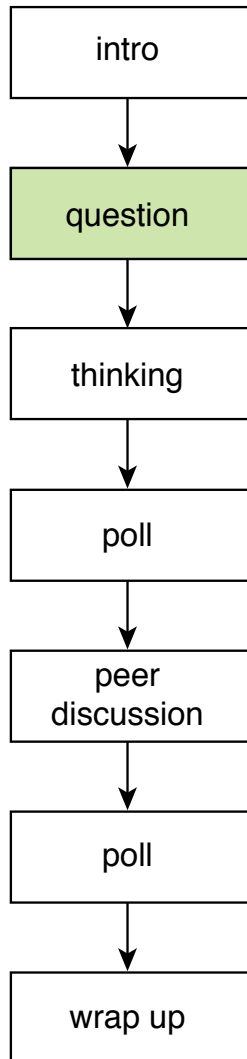
Creating ConcepTests

let's get started: write a stem

- **complete question**

- **avoid common knowledge**

- **avoid negative statements ("not", "no",...)**

Creating ConcepTests

let's get started: add answer choices

```
intro
  ↓
question
  ↓
thinking
  ↓
poll
  ↓
peer
discussion
  ↓
poll
  ↓
wrap up
```

- **aim for 3–5 options**

- **order choices logically**

- **make all roughly same length**

- **avoid repeating words (move to stem)**

- **avoid "All/None of the above", "Other"**

Research Funding:

for more information and a copy of this presentation:

http://mazur.harvard.edu

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