



1 Question

Can software that harnesses cognitive science improve healthcare-provider performance—and patient outcomes?

2 Learner Experience

Test before learning

QUESTION

Isolate the variable term on the left side of the equation:
 $-6y + 9 = 19$

ANSWER

☐ $-6y = 10$

☐ $-6y = 28$

☐ $6y = 28$

☐ $6y = 10$

☐ I DON'T KNOW YET

submit

Confidence rating

QUESTION

Isolate the variable term on the left side of the equation:
 $-6y + 9 = 19$

ANSWER

☒ I AM UNSURE
 $-6y = 10$

☒ I AM UNSURE
 $-6y = 28$

☐ $6y = 28$

☐ $6y = 10$

☐ I DON'T KNOW YET

submit

Immediate valence feedback

QUESTION

Isolate the variable term on the left side of the equation:
 $-6y + 9 = 19$

ANSWER

☒ YOU WERE UNSURE AND ONE IS CORRECT
 $-6y = 10$

☒ YOU WERE UNSURE AND ONE IS CORRECT
 $-6y = 28$

☐ $6y = 28$

☐ $6y = 10$

☐ I DON'T KNOW YET

next question

Short delay to corrective feedback

LEARN

QUESTION

Isolate the variable term on the left side of the equation:
 $-6y + 9 = 19$

ANSWER

☒ YOU WERE UNSURE AND CORRECT
 $-6y = 10$

☒ YOU WERE UNSURE AND INCORRECT
 $-6y = 28$

☐ $6y = 28$

☐ $6y = 10$

☐ I DON'T KNOW YET

WHAT YOU NEED TO KNOW

According to the addition principle, the same operation must be performed on both sides of an equation.

Correct Answer	Steps and Explanation
$-6y = 10$	$-6y + 9 = 19$ Subtract 9 from both sides $-6y + 9 - 9 = 19 - 9$ Remove added and subtracted zeroes $-6y = 10$ This solution adheres to the addition principle.
Incorrect Answers	Steps and Errors $-6y + 9 = 19$ Subtract 9 from the left side but add 9 to the right side $-6y + 9 = 28$ Remove added and subtracted zeroes $-6y = 28$ This solution violates the addition principle.
$6y = 10$	$-6y + 9 = 19$ Subtract 9 from both sides Accidentally drop the negative sign from the left side $6y + 9 = 10$ Remove added and subtracted zeroes $6y = 10$ This solution involves a careless (but common) calculation mistake.
$6y = 28$	$-6y + 9 = 19$ Subtract 9 from the left side but add 9 to the right side Accidentally drop the negative sign from the left side $6y + 9 = 28$ Remove added and subtracted zeroes $6y = 28$ This solution violates the addition principle and involves a careless (but common) calculation mistake.

next

When wrong, question re-asked after longer delay
Question retired after mastery

3 Background

Mistakes made by healthcare workers kill 250,000 people per year in the United States alone. Medical error is the third-leading cause of death in the U. S., behind only heart disease and cancer. The most common cause of medical error is “cognitive failures” (Joint Commission, 2015).

4 Study 1: Hospital-acquired central-line infections (N = 3,712)

Collar Bone

Vein Entry

Exit Site out of Skin

Catheter Tail

Cap

A central line is a thin tube (catheter) placed into a large vein. Central lines are used to administer nutrition or medication (e.g., drugs for chemotherapy), and to monitor central venous pressure during acute care.

When a healthcare provider contaminates the equipment or the entry site, the patient can develop a central-line-associated bloodstream infection (CLABSI). The incidence of CLABSI is expressed in terms of the number of infections caused for every 1,000 days that patients had central lines (“CLABSI per 1,000 line-days”).

Central-line-attending nurses at a healthcare system were trained in the cognitive-science-based Amplifire platform. An example question and its corrective feedback:

QUESTION

What is the most common contamination route for long-term CVCs?

Potential Routes of Infection

- Contaminated Infusate:**
 - Fluid or medication
 - Extrinsic sources
 - Extrinsic sources
 - Manufacturer
- Contamination of catheter hub:**
 - Extrinsic sources (e.g., health care worker)
 - Endogenous flora (e.g., from the skin)
- Skin organisms:**
 - Endogenous flora
 - Extrinsic sources (e.g., health care worker, contaminated disinfectant)
 - Invading wound
- Contamination of device prior to insertion:**
 - Usually extrinsic; rarely manufacturer

Hematogenous: from distant infection

Fibrin sheath, thrombus

ANSWER

☒ Intraluminal spread

☐ Extraluminal spread

☐ Blood-borne spread from remote infection

☐ Contaminated infusates

☐ I DON'T KNOW YET

WHAT YOU NEED TO KNOW

☒ Intraluminal is the most likely contamination route for CVCs with prolonged dwell times. This type of contamination often occurs when the access hubs, IV solution connection sites, needleless connectors, or tubing junctions are contaminated by healthcare personnel hand contact.

☒ Extraluminal contamination is the most common kind of infection for short-term nontunneled catheters (in place less than 10 days). This contamination often occurs when the patient's skin organisms at the insertion site migrate along the surface of the catheter resulting in colonization at the catheter tip.

☒ Catheters can become infected via the blood-borne (hematogenous) route from an infection at another site, such as a urinary tract infection or pneumonia, but this is less common.

☒ Infusates, such as parenteral fluid, blood products, or intravenous medications can become contaminated, but this type of contamination is uncommon.

CLABSI per 1,000 Line-Days

Before: 1.09

After: 0.56

Given CLABSI's mortality rate of 25%, this reduction should save ~13 lives per year.

5 Study 2: Hospital-acquired urinary-catheter infections (N = 4,512)

Bladder

Urine

Balloon

Urethra

Catheter

A urinary catheter is a thin tube inserted into the bladder via the urethra. An indwelling catheter remains in the urethra and bladder for continuous drainage of urine and monitoring of urine output during acute care.

As with central lines, healthcare workers' mistakes can contaminate indwelling urinary catheters. As a result, the patient can develop a catheter-associated urinary tract infection (CAUTI). As with CLABSI, the incidence of CAUTI is expressed in terms of the number of infections caused for every 1,000 days that patients were catheterized (“CAUTI per 1,000 catheter-days”).

Urinary-catheter-attending nurses at the same healthcare system as in Study 1 were trained in Amplifire. An example question and its corrective feedback:

QUESTION

What is the strongest risk factor for CAUTI infection?

ANSWER

☒ Duration of catheterization

☐ Advanced age of the patient (>75 years)

☐ Diabetic patient on diuretics

☐ I DON'T KNOW YET

WHAT YOU NEED TO KNOW

☒ The strongest risk factor for CAUTI is duration of catheterization. Every day with a catheter increases the chance of infection by about 7%, and after a month, the odds of CAUTI approach 100%. The best defense against CAUTI is to not insert an indwelling catheter. If a catheter is necessary, the second best defense is to remove the catheter as soon as it is no longer required.

CAUTI per 1,000 Catheter-Days

Before: 1.29

After: 0.88

Before training, there were 1.29 CAUTI per 1,000 catheter-days. **After** training, there were 0.88 CAUTI per 1,000 catheter-days—a reduction of 32%. An exact Poisson test indicated that the CAUTI rate was statistically significantly reduced after training: $p = .01363$.

Although both CLABSI and CAUTI were reliably reduced, the smaller magnitude of the CAUTI reduction may be attributable to two factors. First, only nurses interact with central lines, but both nurses and technicians interact with urinary catheters; part of the caregiver population was not trained on CAUTI. Second, the CAUTI course did not employ any multimedia (Mayer, 2017). A revised and improved CAUTI course will be distributed to both nurses and technicians in the coming months.

References

Joint Commission (2015). Patient safety. *Joint Commission Online*. Retrieved from <https://goo.gl/CeMeiw>

Mayer, R. E. (2017). Using multimedia for e-learning. *Journal of Computer Assisted Learning*, 33, 403-423.

6 Answer

Yes.