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About this Workshop . . .

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- **The Challenge/Issue**

  Classroom oriented technical training is expensive and requires years of additional on-the-job training to develop expertise.

- **Opportunity**

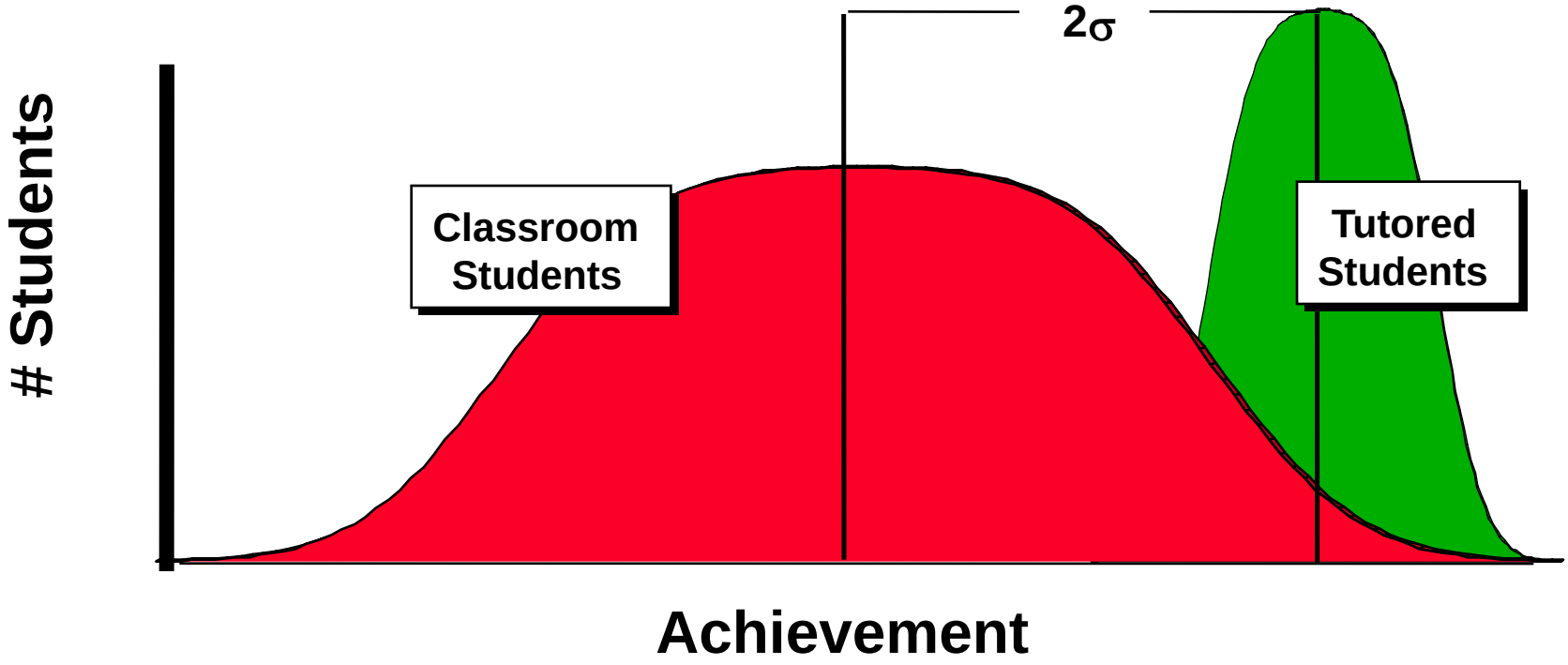
  Digital Tutoring can produce expertise in the same time needed for classroom training.

Workshop Panels

- Suggest common ground and background for discussing Digital Tutors
- Panel One
  - Review the history, characteristics, effectiveness, implementation, and use of Digital Tutors.
- Panel Two
  - Assess the readiness and role of Digital Tutor technology for use in “building America’s skilled technical workforce”.
  - If ready, suggest who needs to do what, where, when, and how to make that happen.
  - If not, suggest what more/next needs to done – if anything

Why Tutoring?

One-on-One Tutoring vrs. Classrooms



(Bloom, 1984)

We can't afford a human tutor for every learner, but we may be able to afford a computer, or a cell phone, or ...

Why Is Tutoring More Effective?

- Interactivity
- Immersion
- Individualization

Hence Computer Assisted Instruction Yesterday (and Today)

In the multiplication 3 X 4 = 12,
the number 12 is called a _____.

A. Factor [Branch to remedial FrameX1]
B. Quotient [Branch to remedial Frame X2]
C. Product [Reinforce, go to next Frame]
D. Power [Branch to remedial Frame X3]

(An Example Frame)

Computer-Assisted Instruction

Two findings from early research:

- **Computers can teach effectively.**
- **Anticipating and then dealing with all possible states of the learner is time-consuming, costly, and impossible.**

The idea:

Perhaps computers can do this 'authoring' themselves

- **In real time**
- **On demand**
- **As tutorial dialogue**

Digital Tutoring

What Do We Mean by Digital Tutoring?

Some defining characteristics (Carbonell, 1970):

- **“Information structures”, not ad-hoc frames**
- **Mixed-initiative dialogue**

A Dialogue from Sophie

Student: What is the base emitter voltage of the voltage limiting transistor?

SOPHIE: The base emitter voltage of Q5 is -.037 volts.

Student: What about for the current limiting transistor?

SOPHIE: The base emitter voltage of Q8 is .349 volts.

Student: What should it be?

SOPHIE: In a working circuit, the base emitter voltage of Q8 is .593 volts.

Student: Replace Q8.

SOPHIE: I am going to ask you some questions about how Q8 is faulted. Are any junctions shorted?

-

(Brown, Burton, & DeKleer, 1982)

Does Digital Tutoring Work?

VanLehn (2011):

- **27 Evaluations**
  - **Effect size of 0.76 for step-based tutoring**

Kulik/Fletcher (2016):

- **50 Evaluations**
  - **Effect size of 0.75 for 39 properly aligned studies**

Effect Sizes

A descriptive statistic commonly used to estimate the magnitude of an effect (e.g., experimental treatment).

$$\text{Effect Size} = \frac{\text{Mean Group 1} - \text{Mean of Group 2}}{\text{Standard Deviation}}$$

Effect Size	Interpretation	(Rough) Percentiles[a]
< 0.25	Negligible[b]	0 – 59th
< 0.40	Small	60th–65th
< 0.60	Moderate	66th–73rd
< 0.80	Large	74th–79th
> 1.00	Very Large	80th and up
> 2.00	Bloom's Challenge[c]	98th and up

[a] Extended from suggestions by Cohen (1988); [b] DoED What Works Clearinghouse (2010); [c] Bloom's Challenge (1984)

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The DARPA Digital Tutor (DT)

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A DARPA Challenge

16 weeks of tutoring to produce sailors greater knowledge and practical skills than sailors with years of experience.

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The DARPA IT Tutor

Why Information Systems Technology?

- An operationally critical competency
- Current training in sore need of improvement (agreement across all echelons)
- An Incredibly Complex Task

Design Features: Strategy

- Thorough front end analysis to determine objectives for expertise
- Modeled on human tutors who are expert in specific IT topics and 1-1 tutoring
- Spiral curriculum with focus on problem solving
- Focus on higher order concepts underlying problem solving processes and solutions
- Integrate with human mentors

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Tutor Design: No Magic Sauce

Known, but high-quality ingredients applied in proportions determined by empirical trial and error.

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Navy Assessment

Groups and Measures

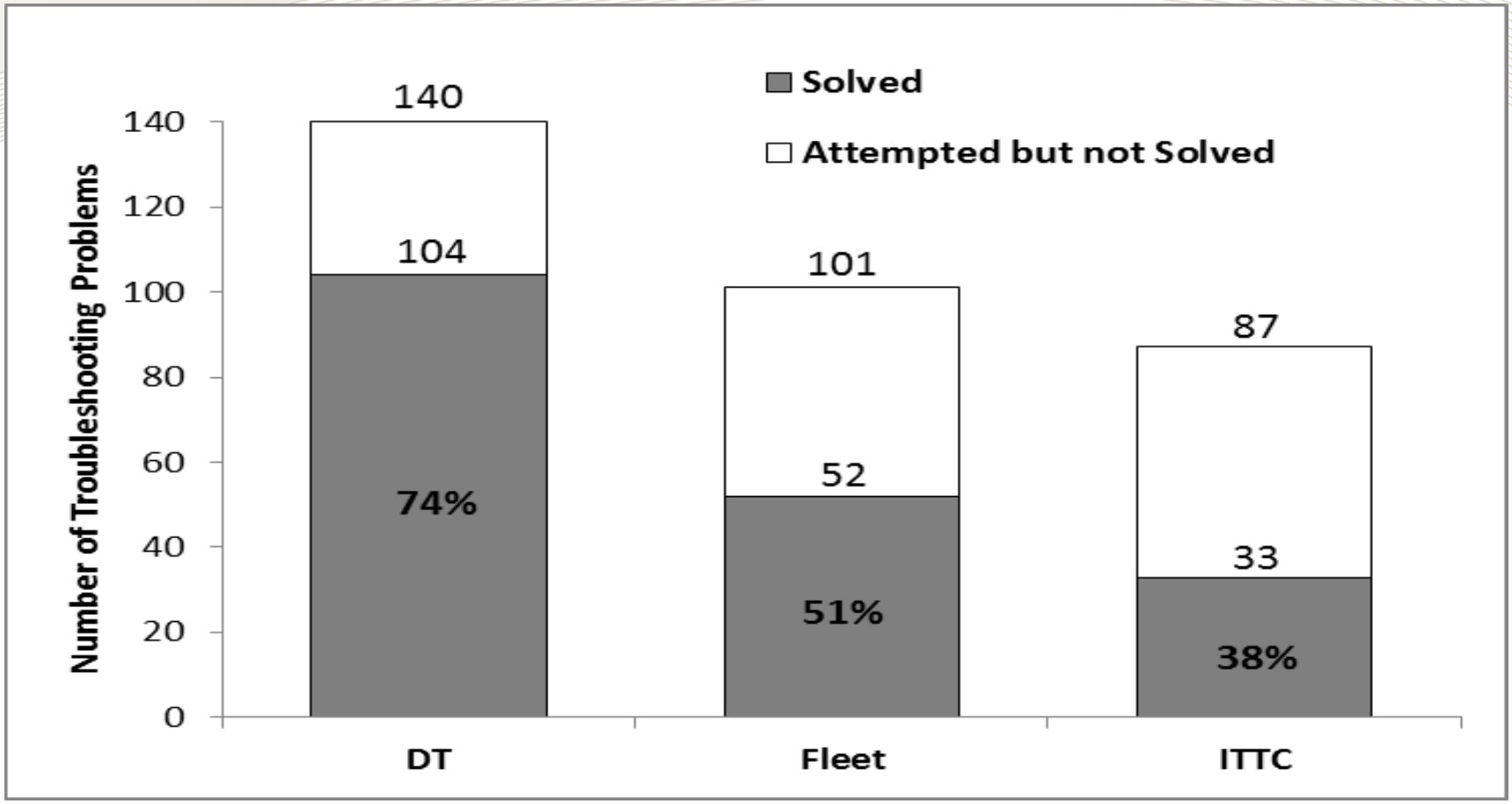
Comparison Groups:

- **16 weeks of the completed DT (N = 12)**
- **35 weeks of IT Training Continuum (ITTC) (N = 12)**
- **Fleet ITs (N = 12) 9.6 Years average IT Experience**

Assessment Measures:

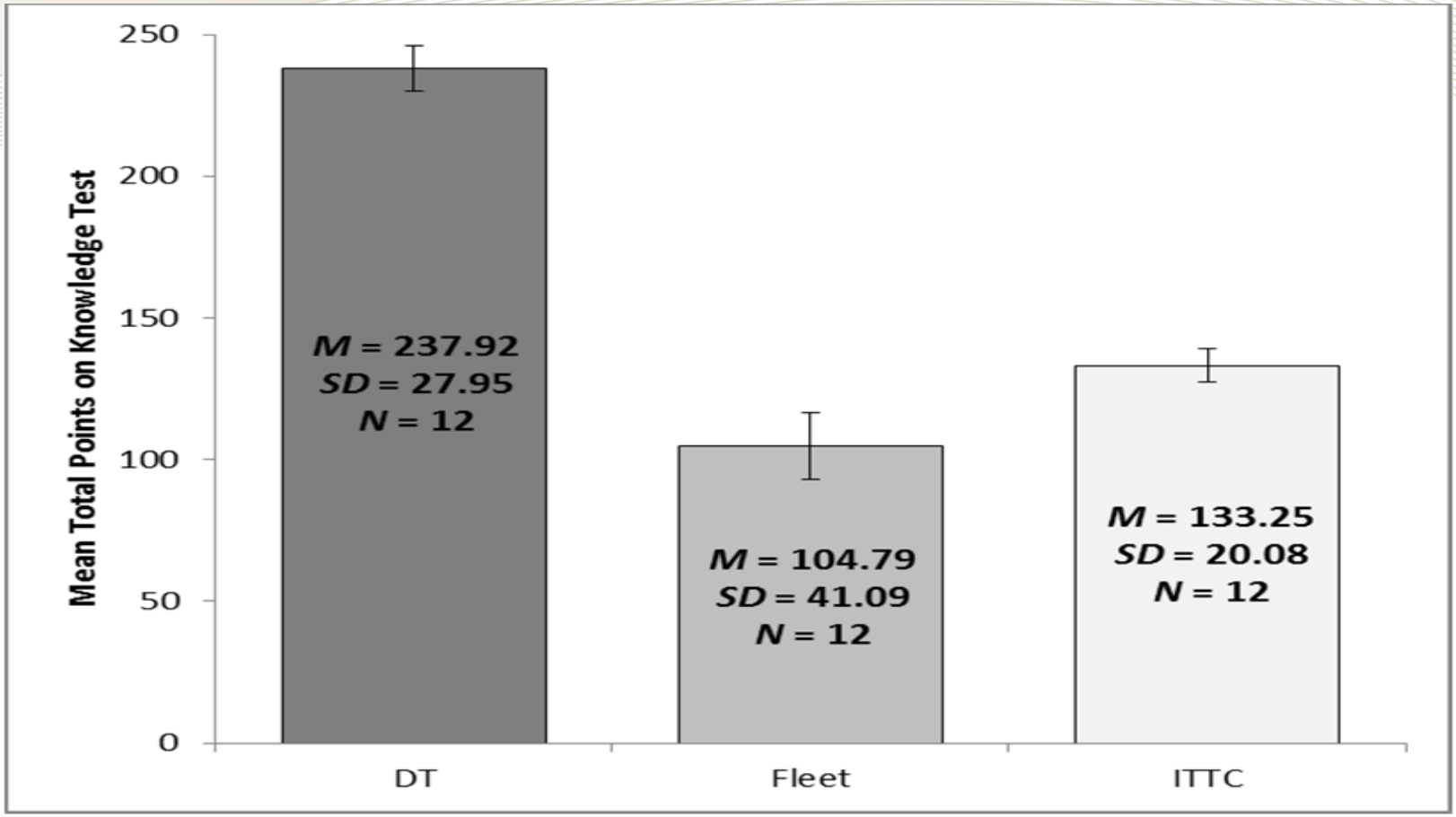
- **6 hours of troubleshooting skill**
- **272-item written knowledge test**

Findings: Troubleshooting Exercises



Solution Quality Total Scores		
	Occur by Chance	Effect Size
DT 132.38 (8.29) > Fleet 70.00 (16.32)	Less than 1 in 10,000	4.19
DT 132.38 (8.29) > ITTC 49.5 (9.72)	Less than 1 in 10,000	7.98

Knowledge Test Scores



Knowledge Test Scores		
	Occur by Chance	Effect Size
DT 237.92 (27.95) > Fleet 104.79 (41.09)	Less than 1 in 10,000	3.66
DT 237.92 (27.95) > ITTC 133.25 (20.08)	Less than 1 in 10,000	4.15

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Veterans Assessment

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The Veterans Project

Objective: Assess use of DARPA Digital Tutor to prepare veterans for civilian IT employment.

- **5 cohorts of 20 Veterans each**

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DT Veteran Characteristics

Average Age	30.5
Civilian IT Ed	8%
Male	91%
Military IT Training	4%
Average Years of Service	5.6
Average Years Separation	5.2
Married	29%
HS/GED Degree Only	45%
Employed	17%
Employed Full Time	11%
Average AFQT	87.1
Honorable Discharge	100%

Results

- 100 Began, 97 Completed, 86 Sought Jobs
- No Academic Dropouts
- Job seekers now confirmed employed: 97%
- Average annual salary $73K (highest, $144)

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Suggested Conclusions …

- We can substantially accelerate the acquisition of technical expertise through Digital Tutoring technology
- The DARPA Digital Tutor suggests a technological breakthrough in this technology
- Digital tutoring represents a major opportunity for enhancing the nation's technical workforce (military and civilian).

Questions? Comments?
Thank you!