ALT- Pathway: Synthetic Tutors in Physics

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Physics Education Seminar
March 12, 2008

Motivation

Benefits of One-on-One Tutoring
- More Effective than Traditional Classrooms (measured by diagnostic tests; "2-Sigma Problem")[1,2]
- Can Reflect a Student-Centered Picture of Learning

1. Bloom (1984)
2. Cohen (1982)

Motivation

Benefits of One-on-One Tutoring
- More Effective than Traditional Classrooms (measured by diagnostic tests; "2-Sigma Problem")[1,2]
- Can Reflect a Student-Centered Picture of Learning

Drawbacks of One-on-One Tutoring
- Lack of Qualified Tutors
- High Labor Cost

1. Bloom (1984)
2. Cohen (1982)

Motivation

Implication:
Human Tutoring is Generally not Feasible

Possible Solution:
Computer-Based Tutoring[3]

3. Reif (1999)

Motivation

Implication:
Human Tutoring is Generally not Feasible

Possible Solution:
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Our Project Goal:
Develop & Test A Web-Based Tutoring Interface

3. Reif (1999)

Motivation

Research Opportunities:

- Scaffolding[4,5]
- Transfer[6]
- Computer-Based vs. Hands-On Experiments[7]

4. Chi, (1996)
5. Chi, (2004)
6. Rebello (2007)
7. Keller (2005)

Why is Tutoring so Effective?

Three Considerations:

Why is Tutoring so Effective?

Three Considerations:

1. The Tutor

Why is Tutoring so Effective?

Three Considerations:

1. The Tutor
2. The Student

Why is Tutoring so Effective?

Three Considerations:

1. The Tutor
2. The Student
3. The Interaction

Why is Tutoring so Effective?

Three Considerations:

1. ~~The Tutor~~
2. The Student
3. The Interaction**???**

In Tutoring Students Can/Must[4,5]:

1. Construct Explanations
2. Ask “Deep” Questions
3. Self-Evaluate

4. Chi, (1996)
5. Chi, (2004)

Why is Tutoring so Effective?

Three Considerations:

1. ~~The Tutor~~
2. The Student
3. The Interaction**???**

While Tutors Failed to[4,5]:

1. Gauge Understanding
2. Recognize Misunderstanding
3. Seize Scaffolding Opportunities

4. Chi, (1996)
5. Chi, (2004)

Cognition and Learning

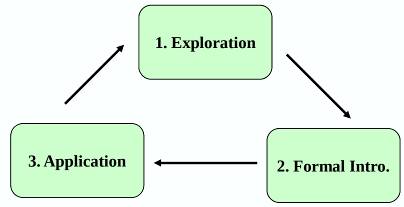
Piagetian Constructivism[8]

- Students Construct Their Own Knowledge
- Students Have Prior Knowledge
- Prior Knowledge Informs Construction

8. Inhelder and Piaget, (1958)

Cognition and Learning

The Learning Cycle[9,10]:



9. Karplus, (1977)
10. Zollman, (1990)

System Design

Teaching Materials: Newtonian Mechanics

Our Short-Term Goal:

Design and Test a Set of Learning Cycles
For Newtonian Mechanics

System Design

Four Learning Cycles

System Design

Four Learning Cycles

1. Newton's 1st Law
2. Newton's 2nd Law
3. Newton's 3rd Law
4. Motion Under Force

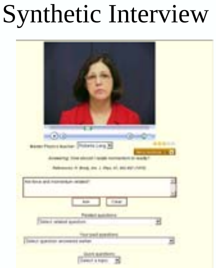
Materials Created with FCI in mind[11]

11. Hestenes, (1992)

System Design

Creating a Virtual Tutor: CMU Technology

Synthetic Interview



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The Story So Far…

This Semester:

Development &Preliminary Test of First Learning Cycle

Newton's First Law

Exploration
- Three Experiments/Observations
- Measurements are Simple, Straight-forward and Precise
- Measurements Follow a Logical Direction

Newton's First Law

Formal Introduction

- TA Facilitates a Discussion of Student Results
- Students Have an Opportunity to Ask Questions

Newton's First Law

Application
- Three Activities
- Focus on Conceptual Understanding (Explanation)
- Focus on Task Completion

Preliminary Testing

Setting: Algebra-based Physics Lab (GP1)

Students: ~270 in 8 Sections Working in Groups of Four

Equipment: One Set-Up per Group

Methods: Observation & Video Recording

Preliminary Testing

Student Reactions:
- Virtually No Difficulty with Completion
- Somewhat Faster/Easier than Normal Labs
- Few Strong Preferences, Much Indifference

Problems:
- Group Work => No Individualized Info.
- Written Words are not Spoken Words
- "Diffusion of Treatment"

Next Step

- Generate Materials for all Learning Cycles
- Do an Extended Study in Algebra-Based Lab
  - Observe & Record “Normal” and Experimental Labs
  - Interview Students, Triangulation
- Study/Interview Individual Users
- Obtain Input From Real High School Teachers

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