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Design, Development and Evaluation of an Interactive Virtual Haptics-Augmented Training System for Undergraduate Engineering

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Design, Development And Evaluation of An Interactive Virtual Haptics-augmented Training System for Undergraduate Engineering

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THE BIG PICTURE

- NSF-funded project
- The Precursors

1. Haptics-Augmented tools designed for K12 education (2003)

- 2-6 grades elementary school students' opinions (N=56)
- Simple machines concepts: i.e. Lever, Pulley, Inclined Plane

2. Haptics-Augmented tools designed for undergraduate engineering education (2007)

- Physics, Statics, and Dynamics
- Freshman and sophomore students at Ohio University,
- Products with physics (N=64), statics (N=15), and dynamics
- (N=21) classes

TWO CONFLICTING THEORIES

- Pavio's (1986) dual-coding theory

  Haptics as an additional sensory channel might be encoded beyond verbal information, which could improve and reinforce learning.

- Cognitive load theory (Sweller, 1994)

  One's working memory is limited in scope and thus any activity that overloads that scope, such as haptics, will be ineffective.

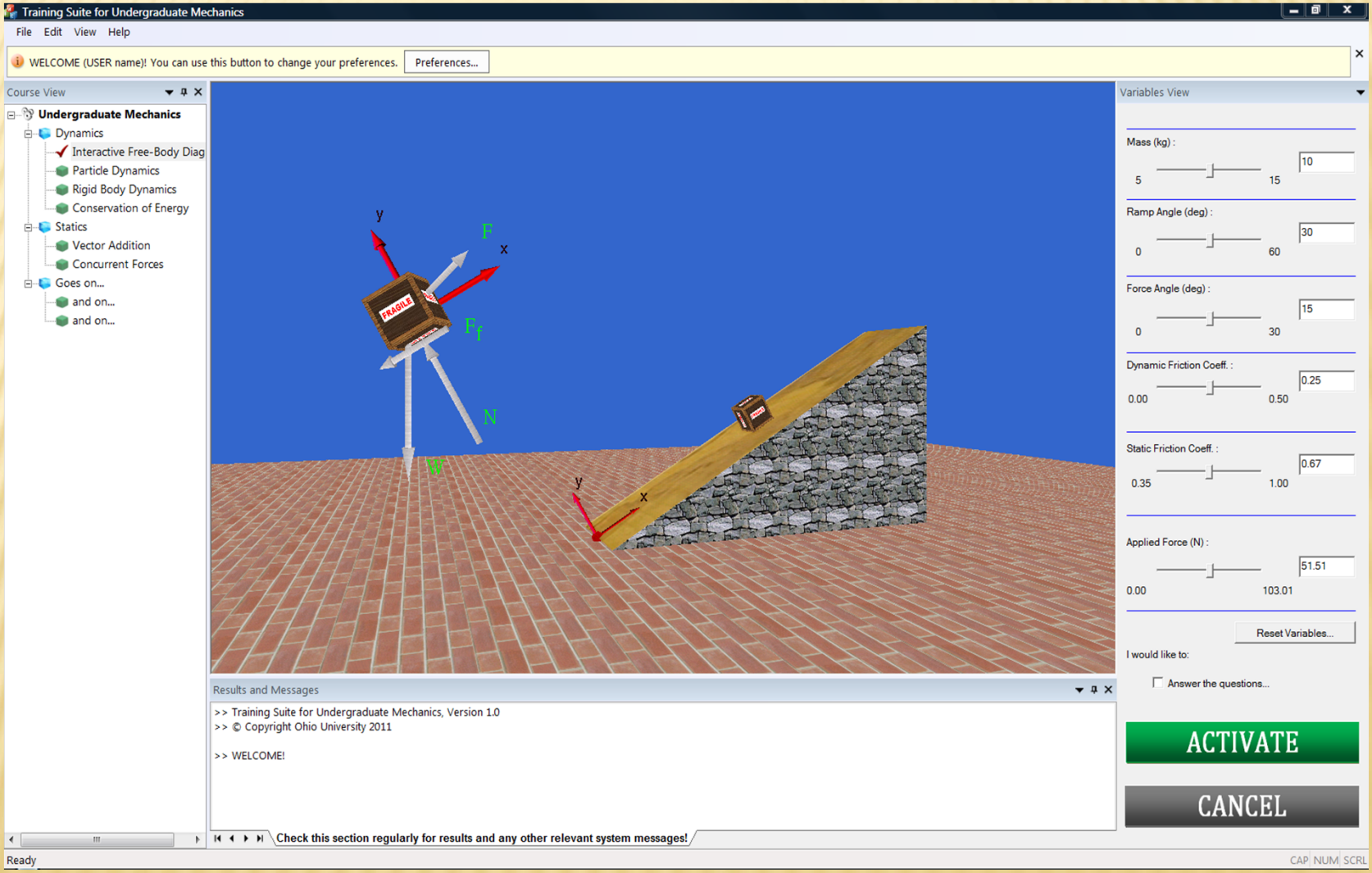
DESIGN PHASES I

Phase	Task	Notes	Timeline
1	Interface Design	on-going revision	Winter 2010-11
1	First Module Design	Interactive Free Body Diagram	Winter 2010-11
1	Tutorial Development	on-going revision	Winter 2010-11
1	Documentation	on-going	Winter 2010-11
2	Test Questions Development	on-going revision	Spring 2010-11
2	Formative Evaluation I (one-to-one evaluation)	with Dr.Bob	Spring 2010-11
2	Formative Evaluation II (small-group evaluation I)	Initial user test with 6 students, revisions made	Spring 2010-11
2	Second Module Design	Rigid Body Diagram	Summer 2010-11

DESIGN PHASES II

Phase	Task	Notes	Timeline
3	Evaluation Protocol Development	on-going revision	Fall 2011-12
3	Formative Evaluation II (user test/small-group evaluation II)	2nd user test with 2 students, revisions made	Fall 2011-12
4	Formative Evaluation III (to test the effectiveness of the software in enhancing students' understanding of abstract haptic concepts)	with two classes of Engineering –major students	Winter 2011-12 Spring 2011-12
5	Analyzing results		Summer 2011-12

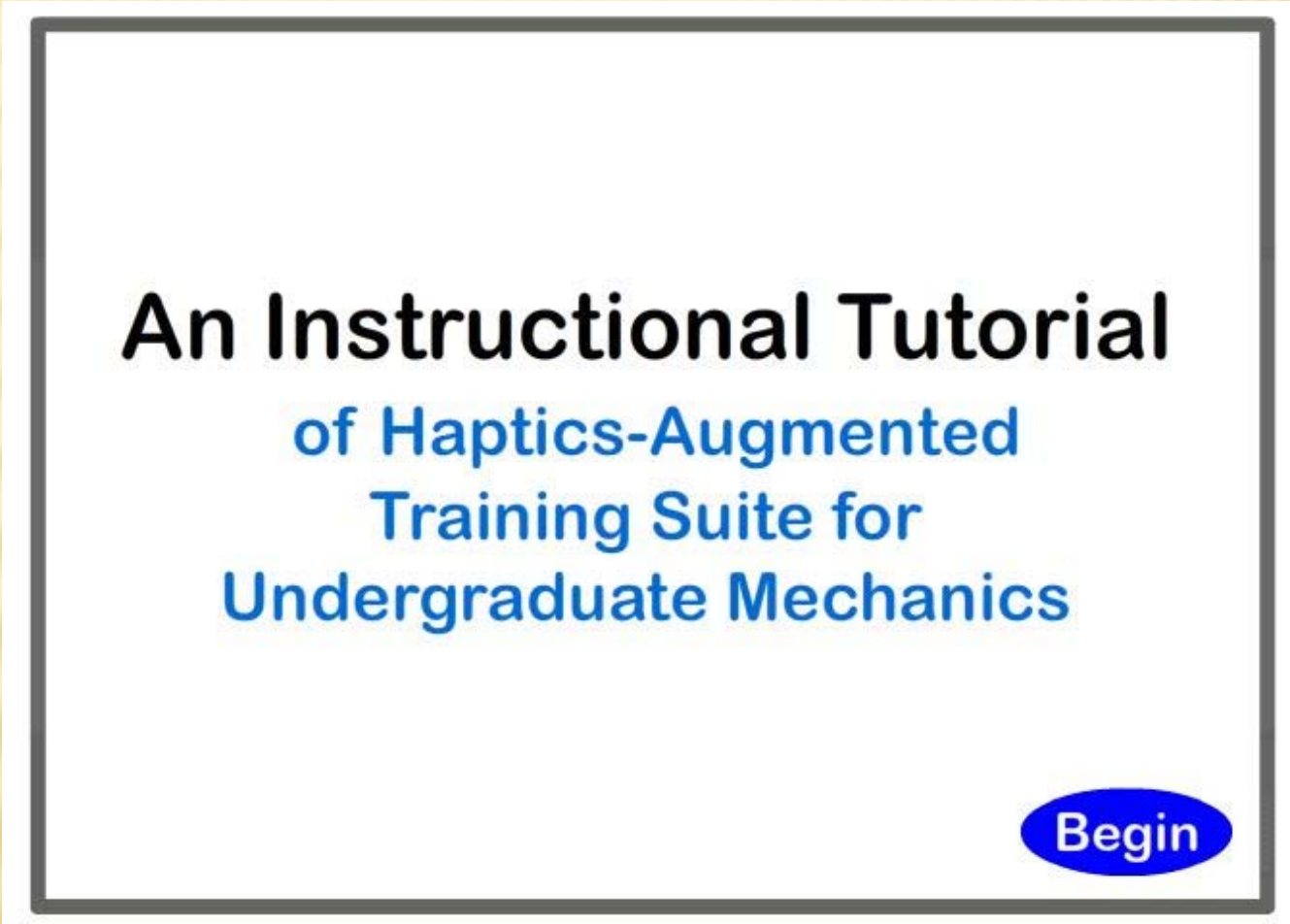
THE INTERFACE



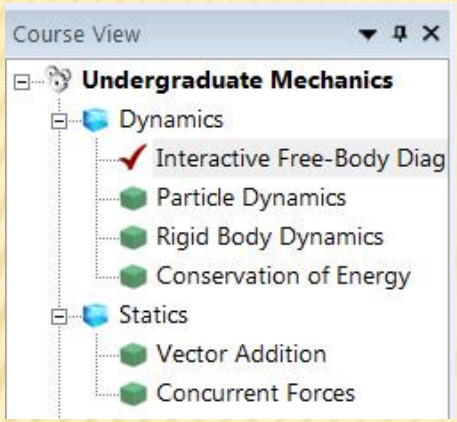
SOFTWARE IMPLEMENTATION

- It is programmed on a PC with Visual C++, OpenGL for graphics, and DirectX for haptic interaction (position input and force output), using a Logitech Force 3D Pro haptic joystick.

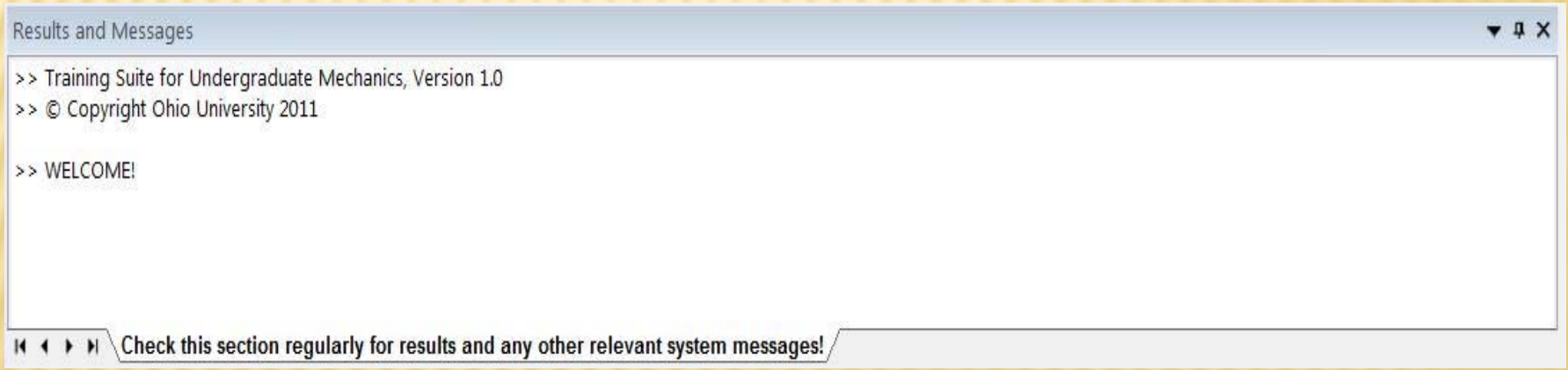
THE TUTORIAL



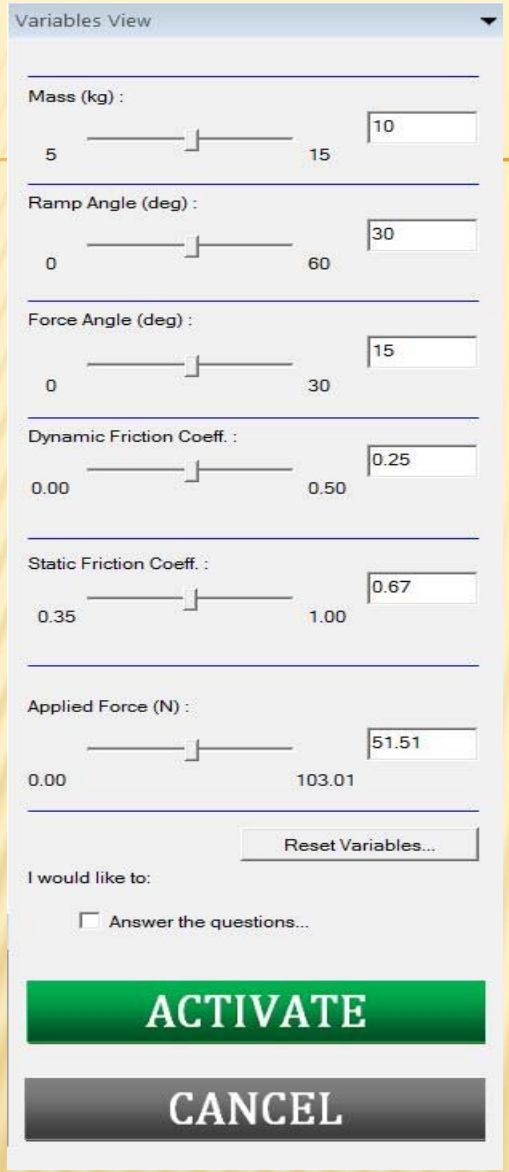
CLOSE-UP

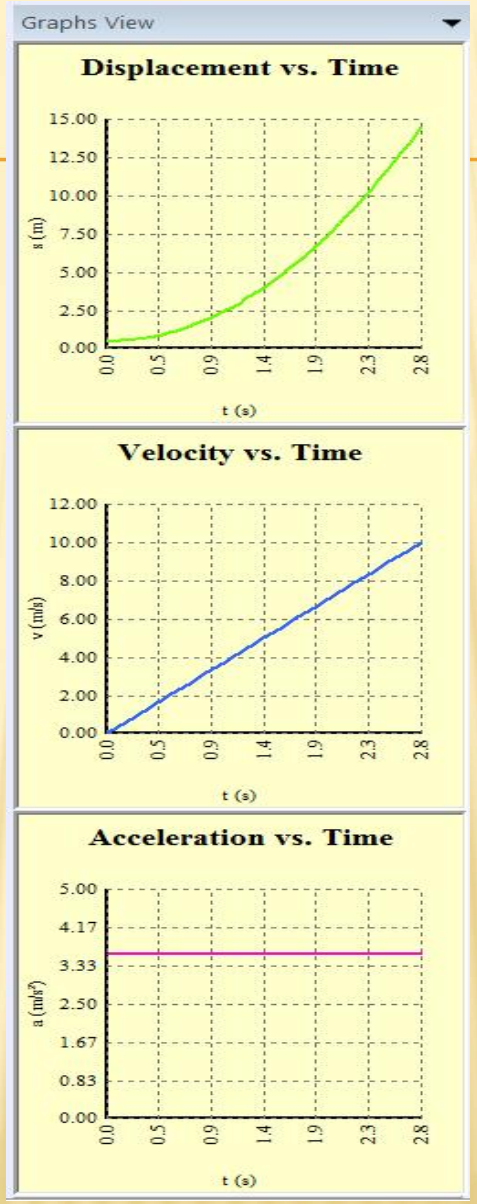


Haptics-Augmented Software Choice Menu



Haptics-Augmented Software Results and Messages Window

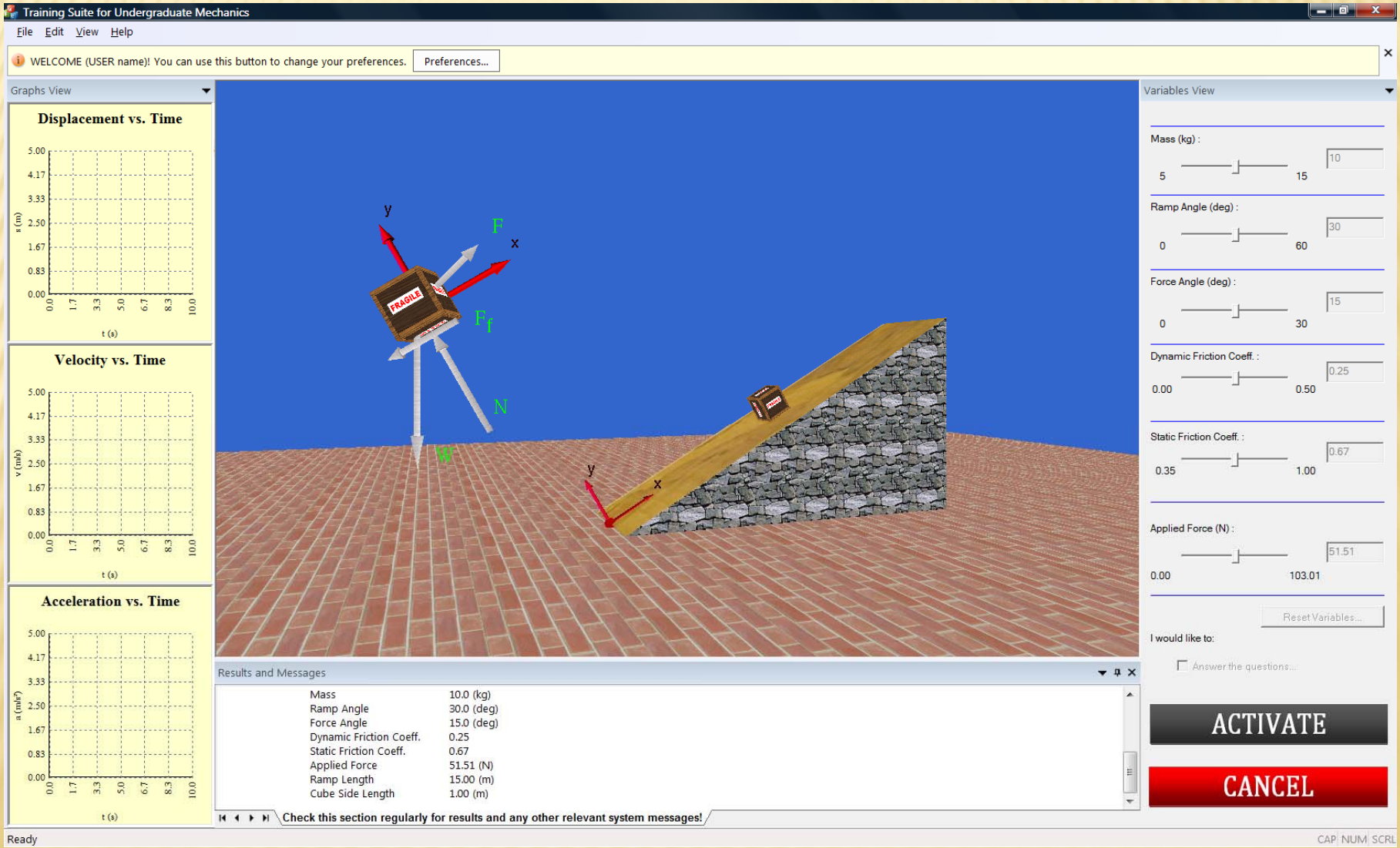




Interactive FBD Variables Window

Interactive Plots Window

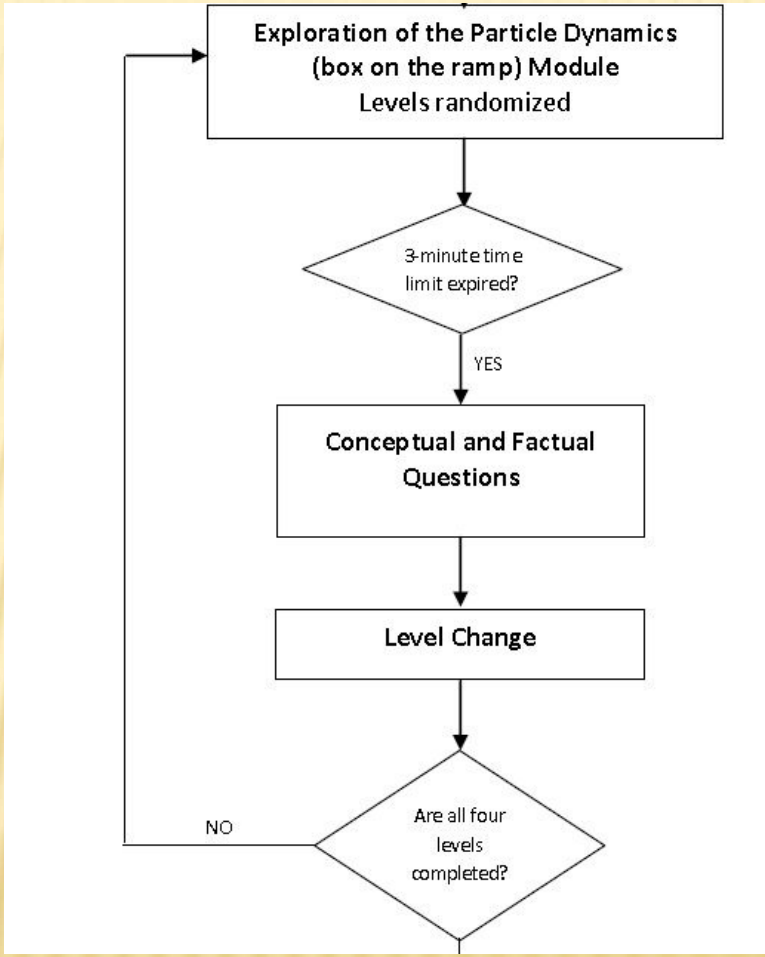
ONCE YOU CLICK ACTIVATE...



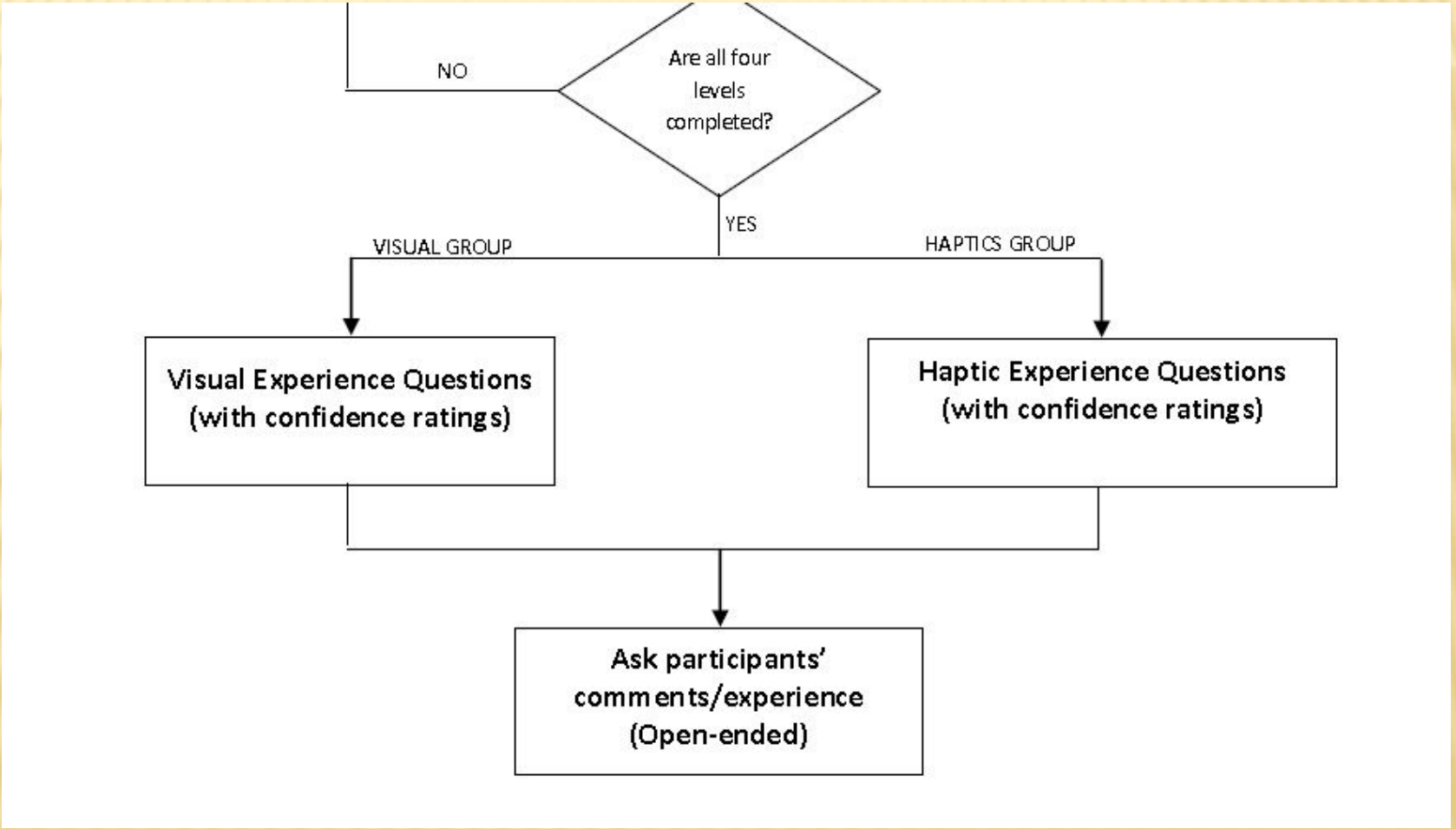
RESEARCH QUESTIONS

- RQ1A: Do participants with haptic augmentation achieve more in reference to **conceptual questions** compared to their visual only counterparts?
- RQ1B: Do participants with haptic augmentation achieve more in reference **to factual questions** compared to their visual only counterparts?
- RQ2: Do participants with haptic augmentation spend more **time-on-task** than visual only participants?
- RQ3: Do participants with haptic augmentation **express more confidence** overall compared to their visual only counterparts?
- RQ4: Do participants with haptic augmentation **express more motivation** compared to their visual only counterparts?

PROCEDURES: STAGE I



PROCEDURES: STAGE II

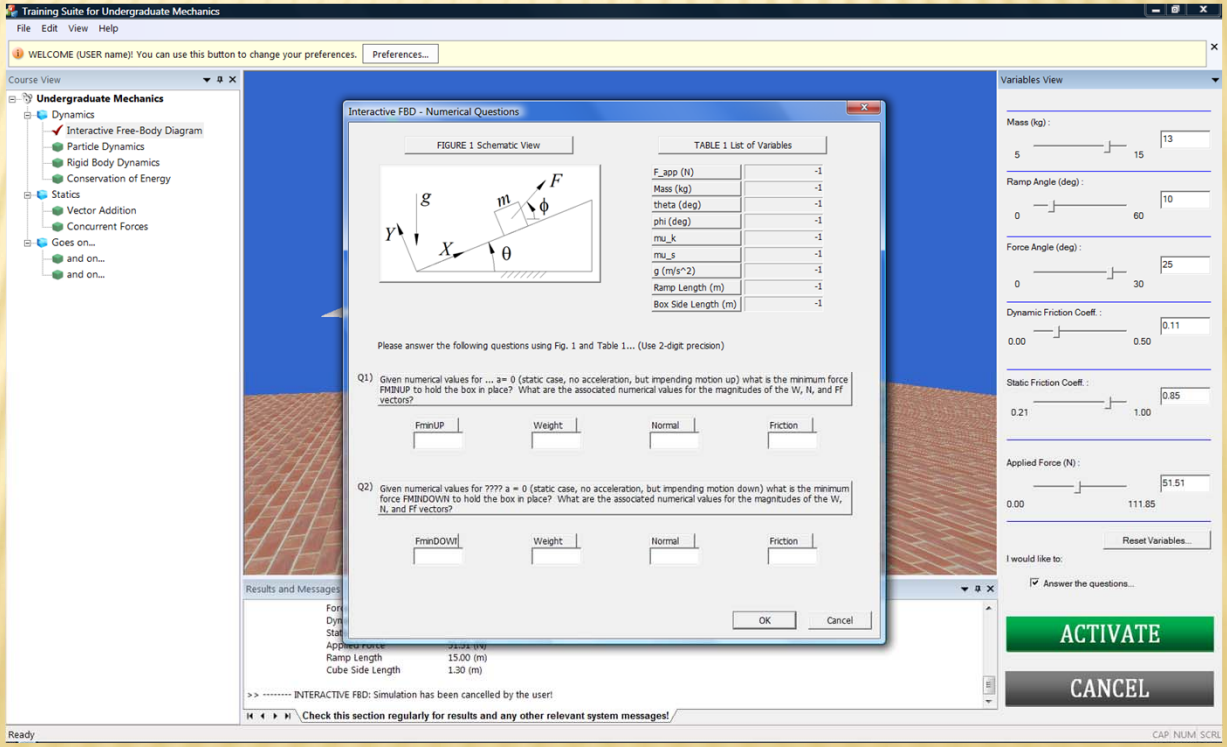


BREAK-DOWN OF EVALUATION QUESTIONS

- Level-specific Test Questions
- Conceptual and factual questions
- Experience Questions (visual vs. haptics)
- Confidence ratings
- Open-ended Questions
- As qualitative data

TWO MAJOR TYPES OF INSTRUMENTS

- Type1: level-specific conceptual and factual questions are presented to test students' understanding of critical dynamic concepts



TWO MAJOR TYPES OF INSTRUMENTS

- Type2: Haptic-only questions that are only pertinent to their haptics experience rather than general factual and conceptual testing questions are asked.
- These questions were designed to distinguish the effect of the haptics from the visual feedback.
- Confidence ratings were added which required students to rate their confidence level of the question they just answered

PARTICIPANTS

- 51 student volunteers
- Engineering majors
- From a large, mid-western, public university
- Aged from 20 to 25 years old
- 43 of 51 have taken a course which provided some prior knowledge

RESULTS

- Achievements

	Haptic group	Visual group
Conceptual (stage 1) p= .036 < .05		Higher
Factual p= .851 > .05	Non-sig	
Experience/Hapitcs-only questions p< .001 < .05		Higher

RESULTS

- Time-on-task

	Haptic group	Visual group
Time spent on the instructional program excluding flash tutorial p= .119 > .05	Non -sig	
Time spent on the Flash tutorial p= .007 < .05	More time	
Stage 1: Time spent in answering conceptual questions p=.111 >.05 Factual questions p= .678> .05	Non -sig	
Stage 2: Time spent on the experience /hapitcs-only section p< .001 < .05	More time	

RESULTS

- Confidence ratings
- Visual group is Higher($p < .001$) < .05
- Motivation
- Haptic group is more motivated

CONCLUSION AND RECOMMENDATIONS

- Our findings indicate that haptic augmentation had limited empirical support.
- With experienced students in higher-order engineering and science fields, haptic-augmentation **contributes little to the learning** of the material and **may in fact inhibit learning.**

CONCLUSION AND RECOMMENDATIONS

- A positive affective and attitude effect
- Caution: Hawthorne Effect
- Indications: Hapics-augmentation could be put to use for populations of students who are at risk for dropping out or moving away from technical and engineering professions.

CONCLUSION AND RECOMMENDATIONS

- Potential reasons
- Many of the concepts we chose to teach were **too simple** for our target population
- Learners were **being provided with too much context** and that context was limiting their interest
- Less-experienced learners may be able to profit more from the haptics-augmentation

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