

Interactive Session: Concept-Based Engineering Education: Designing Instruction To Facilitate Student Understanding Of Difficult Concepts In Science And Engineering

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Abstract - This Interactive Session will provide an active learning environment where participants will:

- Review and analyze the results of three difficult concepts studies in engineering and science,
- Engage in discipline-based discussions about the difficult concepts in their respective fields and,
- Begin to design instruction that fosters student conceptual understanding.

The session will expand upon the successful FIE 03 Interactive Session “Why are Some Science and Engineering Concepts So Difficult to Learn? Identifying, Assessing, and ‘Repairing’ Student Misunderstanding of Important Concepts.” However, participants do not need to have attended that session to benefit from this one.

Index terms – Difficult concepts, misconceptions, interactive session

INTRODUCTION

This session will engage participants in collaborative analysis of cutting-edge engineering education research results. Participants, in discipline-based teams, will then use the research to begin to design instruction that promotes students’ understanding of difficult concepts. The session will expand upon the successful FIE 03 Interactive Session “Why are Some Science and Engineering Concepts So Difficult to Learn? Identifying, Assessing, and ‘Repairing’ Student Misunderstanding of Important Concepts.” However, participants do not need to have attended that session to benefit from this one.

This session will provide a collaborative learning environment where participants will:

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SESSION TOPICS AND TIMELINE

Participants will be assigned to teams based on their discipline (mechanical engineering, industrial engineering, etc) and will work in these teams throughout the workshop. This will provide the opportunities for participants to discuss the fundamental concepts in their field with colleagues at other institutions.

The session will address three questions:

- (1) What are some of the fundamental difficult concepts in engineering?
(about 45 minutes will be devoted to this activity)

Participants will receive the results of Delphi studies of difficult concepts that have been conducted by the authors in three areas: (a) the thermal and transport sciences (heat transfer, thermodynamics and fluid mechanics), (b) engineering mechanics (statics, dynamics and strengths of materials) and (c) electrical engineering (focusing on circuits).

In their teams, participants will discuss the results and

- Look for areas of overlap between the three areas,
- Discuss the validity of the results based on their experience as instructors,
- Pick 1-3 difficult concepts they want to continue to discuss as a group.

- (2) What theoretical framework can be used to explain why some concepts are so difficult to learn? (about 30 minutes will be devoted to this activity)

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The presenters will provide a brief summary of work in this area - highlighting the work of Dr. Michelene Chi (noted cognitive psychologist) and Dr. David Hestenes (author of the Force Concept Inventory).

- (3) How might we design instruction to help students better understand difficult concepts?
(about 45 minutes will be devoted to this activity)

Again in teams, and using the 1-3 difficult concepts they selected in Activity 1, participants will begin to develop a plan for designing instruction to better help students understand these difficult concepts.

EXPECTED OUTCOMES (LEARNING OBJECTIVES)

- Participants will be familiar with the most recent research on the subject of difficult concepts in engineering.
- Participants will have begun a plan to design instruction that fosters student understanding of difficult concepts.

RELATED PEER-REVIEWED PAPERS BY SESSION PRESENTERS

Precursors to this work have been presented by the authors at FIE 2002 [1] and 2003 [2, 3], and at ASEE 2003 [4] and 2004 [5]. The references for these works are listed below.

[1] Evans, D.L., Midkiff, C., Miller, R., Morgan, J., Krause, S., Martin, J., Notarus, M., Rancour, D., & Wage, K. (November, 2002). Tools for assessing conceptual understanding in the engineering sciences. *Proceedings of the Frontiers in Education conference, Boston, MA.*

[2] Evans, D.L., Gray, G.L., Krause, S., Martin, J., Midkiff, C., Notaros, B.M., Pavelich, M., Rancour, D., Reed-Rhoads, T., Steif, P., Streveler, R., Wage, K., (November, 2003). *Progress on concept inventory assessment tools.* Proceedings of the Frontiers in Education conference, Boulder, CO.

[3] Streveler, R. A., Nelson, M.A., Olds, B.M., & Miller, R.L. (November, 2003). *Why are some science and engineering concepts so difficult to learn? Identifying, assessing, and "repairing" student misunderstanding of important concepts.* Special Session at the Frontiers in Education conference, Boulder, CO.

[4] Streveler, R.A., Olds, B.M., Miller, R. L. & Nelson, M.A. (June, 2003). Using a Delphi Study to identify the most difficult concepts for students to master in thermal and transport science. *Proceedings of the Annual Conference of the American Society for Engineering Education, Nashville, TN.*

[5] Olds, B.M., Streveler, R.A., Miller, R.L., & Nelson, M.A. (June, 2004). Preliminary results from the development of a concept inventory in thermal and transport science. *Annual Conference of the American Society for Engineering Education, Salt Lake City, UT.*