Discipline based education research (DBER) in Engineering

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Prof. Dr Mira Vukčević

The goals of DBER

- To understand how people learn the concept, practices and ways of thinking about science and engineering,
- Development of early expertise in a discipline,
- Identify appropriate Learning outcomes and instructional approaches toward the objectives,
- Identify approaches that will make engineering education broad and inclusive.

The practical areas of inquiry for engineering education

- The extent to which engineering faculties adopt evidence-based practice,
- The extent to which the faculty takes a scholarly approach to teaching and learning or envision a developmental process for learning and inquiry,
- The extent of collaboration with researchers and learning scientists,
- The implicit and explicit values that faculty culture place on teaching and learning compared with traditionally disciplinary research,
- Development of teaching and learning knowledge skills,
- How future engineers understand the nature of engineering work, early in their careers but also across the career span,
- How well the curriculum and instructions prepare students to understand the complexity of engineering problem solving.

Understanding and improving learning in engineering, students learning criteria

Ability to apply knowledge in basic disciplines	• **Conceptual understanding needed for conceptual change**
Ability to design and conduct experiment, to analyze and interpret data	• **Understanding, problem solving, transfer**
Ability to design the system, components or process to meet desired needs	•**Problem solving**
Ability to identify, formulate and solve the engineering problem	• **Metacognition, practice**
Ability to communicate, understanding of social context, use the techniques, skills and modern tools necessary for engineering practice	**.Transfer, practice**

Key findings on conceptual understanding

Difficulty to understand	• **Students have difficulty to understand phenomena and interactions that are not observable, including those that involve very large or very small spatial or temporal scales,** • **Misunderstandings and wrong beliefs about the key concepts. Vital for students is to address the key concepts and practices of a discipline**
Variety of strategies needed	▪ **A variety of teaching strategies is needed to help students to replace incorrect ideas: Interactive lecture demonstration, interventions that target specific misconceptions, bridging analogies that link students' understanding and the situation of misconception**

Changing students conception about heat transfer

Misconception	**Students often believe that heat is substance rather then energy transfer. Gathering students in 3 laboratories to address very specific heat transfer misconceptions**
Action	**• First laboratory activity-working with boiling liquid nitrogen to address misconception that the temperature is a good indicator of total energy as opposed to kinetic energy** **• Second laboratory activity compared heat transfer in chipped versus block ice to address the misconception that more heat is transferred if reaction is faster** **•Third laboratory involved cooling of heated blocks with ice to help students distinguish between rate and amount of heat transfer** **Result: conceptual understanding change at least at short-term run**

Improving conceptual understanding

- Translating the problems into the visual representation and then into a mathematical representation is important step in solving problems,
- Dependence on ritualistic algorithmic problem solving rather then understanding. Inability to even recognize the problem,
- When students encounter difficulty in problem solving they have to learn to consider alternative procedure for figuring out the answer,
- Effective instructional strategy in this case would be to provide a compelling example of how much difference a good representation can make for the solution, provide one such example.

Summary of key findings

- DBER clearly indicates that student-centered instructional strategies can positively influence learning, achievements, and knowledge retention as compared with traditional instructional methods,
- Research on the use of various learning technologies suggests that technology can enhance students' learning process and attitudes about science learning. However the presence of technologies alone does not improve the outcomes. The outcomes appear to depend on how the technology is used,
- Despite the importance of laboratories in science and engineering education (especially undergraduate one), their role in student' learning is still unexamined.

Practices to be applied in undergraduate education

- Asking questions and defining problems,
- Developing and using models,
- Planning and carrying out investigations,
- Analyzing and interpreting data,
- Using mathematics and computational thinking,
- Constructing explanations and designing solutions,
- Engaging in argument from evidence,
- Obtaining, evaluating and communication information.

Students' proficiency with practices

- Regarding practices as an outcome, undergraduate students have little experience or expertise in aspects of designing or conducting scientific investigations that are important to practicing scientists and engineers.

Students struggle to:

- **Distinguish between data and evidence,**
- **Classify matter,**
- **Ask fruitful questions,**
- **Make predictions, observations and explanation**
- **Understand experimental uncertainty unless they are explicitly taught about it**

Potential instructional approaches

- The use of undergraduate research experience and internship to supplement the traditional learning experience,
- Apprenticeship model, acquiring skills doing bench science, learning to use analytical instruments, modelling programs, field work,
- Students who participate in undergraduate research believe that they have enhanced their research skills and are more motivated to pursue a career in science.

Future research in DBER in ENGINEERING

- How to measure and promote proficiency and to explore relationship among practice and other outcome such as overall understanding of concepts, practices and ways of thinking,
- Discipline specific variations and taking them into account when studying students’ learning,
- Thinking about the process and mechanism in which the outcomes are achieved (time/money balance in programs exhibition),
- Thinking about the research experience during the scholastic year not during apprenticeship or other practices,
- Explore the wider variety of opportunities, industry settings, service learning.

Reference

Susan.R. Singer et all “Discipline based education research: Understanding and improving Learning in Undergraduates Science and Engineering” (2012)

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Thank you for your attention