Rutgers, The State University of New Jersey

15:256:557:01 Multiple Representations in Physical Science
Spring 2015
Monday, 4:50-7:30
GSE, 211

Instructor: Robert Zisk	robert.zisk@gse.rutgers.edu
Phone Number 732 672 9432	10 Seminary Pl Rm 013
Office Hours: by appointment	Prerequisites or other limitations: "Development of Ideas in Physical Science"; "Teaching Physical Science"
Mode of Instruction: ___ Lecture __X_ Seminar ___ Hybrid ___ Online ___ Other	Permission required: _x_ No __Yes Directions about where to get permission numbers: from the instructor

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Course Description

Learning goals

1. To connect learning of physics with the structure and function of the brain.
2. To apply the knowledge of brain science and cognitive science to problem solving in a physics class.
3. To master different ways to engage diverse students in meaningful problem solving in every unit of a high school physics/physical science course focusing specifically on formative assessment and self-assessment.
4. To deepen your own understanding of physics concepts, relations and multiple representations.

New Jersey Professional Standards for Teachers (2014)[1]:

Standard One: Learner Development. The teacher understands how learners grow and

[1] http://www.state.nj.us/education/code/current/title6a/chap9.pdf

develop, recognizing that patterns of learning and development vary individually within and across the cognitive, linguistic, social, emotional, and physical areas, and designs and implements developmentally appropriate and challenging learning experiences.

Performances:

(1) The teachers regularly assesses individual and group performance in order to design and modify instruction to meet learners' needs in each area of development (cognitive, linguistic, social, emotional and physical) and scaffolds the next level of development

Essential Knowledge:

(1) The teacher understands how learning occurs – how learners construct knowledge, acquire skills and develop disciplined thinking processes - and knowledge how to use instructional strategies that promote student learning

(2) The teacher understands that each learner's cognitive, linguistic, social, emotional and physical development influences learning and knows how to make instructional decisions that build on learners' strengths and needs

(4) The teacher understands the role and impact of language and culture in learning and knows how to modify instruction to make language comprehensible and instruction relevant, accessible and challenging.

Critical Dispositions:

(2) The teacher is committed to using learners' own strengths as a basis for growth and their misconceptions as opportunities for learning

(3) The teacher takes responsibility for promoting learners' growth and development

Standard Two: Learning Differences. The teacher uses understanding of individual differences and diverse cultures and communities to ensure inclusive learning environments that enable each learner to meet high standards.

Performances:

(1) The teacher designs, adapts and delivers instruction to address each student's diverse learning strengths and needs and creates opportunities for students to demonstrate their learning in different ways

(3) The teacher designs instruction to build on learners' prior knowledge and experiences, allowing learners to accelerate as they demonstrate their understandings

Essential Knowledge:

(2) The teacher understands and identifies differences in approaches to learning and performance and knows how to design instruction that uses each learner's strengths to promote growth;

(5) The teacher understands that learners bring assets for learning based on their individual experiences, abilities, talents, prior learning and peer and social group interactions, as well as language, culture, family and community values

Critical Dispositions:

(1) The teacher believes that all learners can achieve at high levels and persists in helping each learner reach his or her full potential.

(3) The teacher makes learners feel valued and helps them learn to value each other.

Standard Three: Learning Environments. The teacher works with others to create environments that support individual and collaborative learning, and that encourage positive social interaction, active engagement in learning, and self motivation.

Performances:

(2) The teacher develops learning experiences that engage learners in collaborative and self-directed learning and that extend learner interaction with ideas and people locally and globally

Essential Knowledge:

(1) The teacher understands the relationship between motivation and engagement and knows how to design learning experiences using strategies that build learner self-direction and ownership of learning.

Critical Dispositions:

(2) The teacher values the role of learners in promoting each other's learning and recognizes the importance of peer relationships in establishing a climate of learning

(3) The teacher is committed to supporting learners as they participate in decision-making, engage in exploration and invention, work collaboratively and independently and engage in purposeful learning

Standard Four: Content Knowledge. The teacher understands the central concepts, tools of inquiry, and structures of the discipline(s) he or she teaches, particularly as they relate to the Common Core Standards and the New Jersey Core Curriculum Content Standards and creates learning experiences that make these aspects of the discipline accessible and meaningful for learners to assure mastery of the content.

Performances:

(1) The teacher effectively uses multiple representations and explanations that capture key ideas in the discipline, guide learners through learning progressions, and promote each learner's achievement of content standard**s;**

(4) The teacher stimulates learner reflection on prior content knowledge, links new concepts to familiar concepts, and makes connections to learners' experiences;

Essential Knowledge:

(1) The teacher stimulates learner reflection on prior content knowledge, links new concepts to familiar concepts, and makes connections to learners' experiences;

(3) The teacher stimulates learner reflection on prior content knowledge, links new concepts to familiar concepts, and makes connections to learners' experiences;

Standard Six: Assessment. The teacher understands and uses multiple methods of assessment to engage learners in examining their own growth, to monitor learner progress, and to guide the teacher's and learner's decision-making.

Performances:

(1) The teacher balances the use of formative and summative assessment as appropriate to support, verify, and document learning;

Essential Knowledge:

(1) The teacher understands the differences between formative and

summative applications of assessment and knows how and when to use each;

Standard Seven: Planning for Instruction. The teacher plans instruction that supports every student in meeting rigorous learning goals by drawing upon knowledge of content areas, curriculum, cross-disciplinary skills, and pedagogy, as well as knowledge of learners and the community context.

Performances:

(1) The teacher individually and collaboratively selects and creates learning experiences that are appropriate for curriculum goals and content standards, and are relevant to learners;

(3) The teacher develops appropriate sequencing of learning experiences and provides multiple ways to demonstrate knowledge and skill;

Essential Knowledge:

(1) The teacher understands content and content standards and how these are organized in the curriculum;

(3) The teacher understands learning theory, human development, cultural diversity, and individual differences and how these impact ongoing planning;

Standard Eight: Instructional Strategies. The teacher understands and uses a variety of instructional strategies to encourage learners to develop deep understanding of content areas and their connections, and to build skills to apply knowledge in meaningful ways.

Performances:

(2) The teacher continuously monitors student learning, engages learners in assessing their progress, and adjusts instruction in response to student learning needs;

(4) The teacher varies his or her role in the instructional process (for example, instructor, facilitator, coach, and audience) in relation to the content and purposes of instruction and the needs of learners;

Essential Knowledge:

(3) The teacher knows when and how to use appropriate strategies to differentiate instruction and engage all learners in complex thinking and meaningful tasks;

Council for the Accreditation of Education Professionals (2013)[2]:

Standard One: Content and Pedagogical Knowledge

1.1 Candidates demonstrate an understanding of the 10 InTASC standards at the appropriate progression level(s)2 in the following categories: the learner and learning; content; instructional practice; and professional responsibility.

- Learner Development
- Learning Environments
- Content Knowledge

[2] http://caepnet.files.wordpress.com/2013/09/final_board_approved1.pdf

- Application of Content
- Instructional Strategies

Course catalogue description

Acquaints prospective and in-service high school physics/chemistry teachers with the multiple representations method used in constructing concepts and teaching the concepts in physical science. Multiple representations are a powerful tool that aids the brain during concept acquisition and problem solving. Multiple representations enhance metacognition and epistemic cognition. Being familiar with the multiple representations used in a discipline is crucial for mastering and teaching it. Focus is on such representations as pictorial representations, motion and force diagrams, graphs, energy bar charts, and applications of these representations to problem solving.

Class materials:
A set of papers from the Reading List additional papers will be posted on the class website:
https://sites.google.com/a/gse.rutgers.edu/multiple-representations-in-physical-science/home
E. Etkina, M. Gentile, & A. Van Heuvelen, College Physics, Pearson, San Francisco, 2014 with the ALG and IG .
J. Zull, *The art of changing the brain*. Sterling, VA: Stylus Publishing. 2002.
J. Zull, *From brain to mind.* Sterling, VA: Stylus Publishing. 2011.
Physics Union Mathematics (PUM) Curriculum modules, to download the modules and final assessment go to http://pum.rutgers.edu then click on Teacher Resources, then Resources for Teachers. *Please make sure you have all HS modules downloaded before the semester starts.* If you do not have access to the PUM modules, please let me know ASAP.

ActivPhysics by A. Van Heuvelen [available on-line] at http://wps.aw.com/aw_young_physics_11
PHET resource by University of Colorado, Boulder: http://phet.colorado.edu
Web sites with class activities: http://paer.rutgers.edu/pt3 and http://paer.rutgers.edu/scientificabilities

PLEASE IF YOU OWN A LAPTOP, BRING IT TO ALL CLASS MEETINGS, MAKE SURE YOU CAN ACCESS ALL OF THESE WEBSITES AND HAVE THE SOFTWARE TO USE THE RESOURCES

Optional, but is a good resource
A. Arons, Teaching Introductory Physics, Wiley&Sons, 1997. ISBN 978-0471137078

Class website https://sites.google.com/a/gse.rutgers.edu/multiple-representations-in-physical-science/home

Reading List

1. Gentner, D., & Gentner, D. R. (1983). Flowing waters or teeming crowds: Mental models of electricity. In D. Gentner & A. L. Stevens (Eds.), *Mental models* (pp. 99-129). Hillsdale, NJ: Lawrence Erlbaum Associates. (Reprinted in M. J. Brosnan (Ed.), *Cognitive functions: Classic readings in representation and reasoning*. Eltham, London: Greenwich University Press).
2. Glynn, S. M., Duit, R., & Thiele, R. (1995). Teaching science with analogies: A strategy for constructing knowledge. In Glynn, S. M., & Duit, R., Eds. *Learning science in schools: Research reforming practice*. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers 247 - 271.

3. Van Heuvelen, A. (1991). Learning to think like a physicist: A review of research-based instructional strategies. *American Journal of Physics*, 59 (10), 891 - 897.
4. Van Heuvelen, A. And Xou, X. (2001). Multiple Representations of Work-Energy Processes, *American Journal of Physics,* 69 (2), 184 - 194.
5. Van Heuvelen, A. and Maloney, D. P. (1999). Playing Physics Jeopardy, *American Journal of Physics,* 67*,* 252 - 257.
6. Etkina, E., Warren, A., & Gentile, M. (2005). The role of models in physics instruction. The Physics Teacher, 44 (1), 34-39.
A series of papers that can be downloaded from the Physical Review Special Topics Physics Education Research website: http://prst-per.aps.org/

Suggested Extra Reading

7. N. D. Finkelstein, W. K. Adams, C. J. Keller, P. B. Kohl, K. K. Perkins, N. S. Podolefsky, S. Reid, and R. LeMaster, Phys. Rev. ST Phys. Educ. Res , **1**, 010103 (2006).
8. W. K. Adams, K. K. Perkins, N. S. Podolefsky, M. Dubson, N. D. Finkelstein, and C. E. Wieman, Phys. Rev. ST Phys. Educ. Res , **1**, 010101 (2006).
9. L. Ding, R. Chabay, Bruce Sherwood, and R. Beichner, Phys. Rev. ST Phys. Educ. Res. **2**, 010105 (2006).
10. G. Kortemeyer Phys. Rev. ST Phys. Educ. Res. **3**, 010101 (2007).
11. N. S. Podolefsky and N. D. Finkelstein Phys. Rev. ST Phys. Educ. Res. **3**, 010109 (2007).
12. S. J. Pollock, N. D. Finkelstein, and L. E. Kost Phys. Rev. ST Phys. Educ. Res. **3**, 010107 (2007).
13. D. T. Brookes and E. Etkina Phys. Rev. ST Phys. Educ. Res. **3**, 010105 (2007).
14. J. Tuminaro and E. F. Redish Phys. Rev. ST Phys. Educ. Res. **3**, 020101 (2007).

Grading policy:

Evaluation of Written Work:

Your course final grade will be based on how you meet the standards listed below. Each standard will be assessed multiple times according to the rubric. If at any point you fail to meet the standard, you will have an opportunity to be assessed again. **Each assignment can be improved.** I encourage you to try as many times as you need to make the assignment perfect.

Each assignment will be scored using the following rubric:
1 – does not meet expectations
2 – moving towards meeting expectations
3 – meets expectations
4 – exceeds expectations (I want to brag about you).

I believe that every student in this course will work to exceed my expectations.

Your course grade is based on meeting each of the standards. The grade breakdown is as follows:

A - 97% of standards met
B+ - 90% of standards met
B - 85% of standards met
C+ - 80% of standards met
C - 75% of standards met
D - 70% of standards met

General standards:

GS1: Is familiar with NJ Science Core Curriculum Standards and NGSS and can use them when planning instruction.
GS2: Is able to connect recommendations of brain research to physics instruction, specifically to interpret literature recommendations and apply to specific instructional moves.
GS3: Is able to interpret student responses (oral or written) and revise planned instruction based on the responses during microteaching.
GS4: Is able to collect (or to describe) evidence that will indicate that students achieved a proposed goal.
GS5: Is able to write a problem-solving multiple representations oriented lesson plan that has all required elements and implement the lesson in practice.
GS6: Is able to devise a beginning of a problem-solving lesson that builds on student ideas and engages them in meaningful application of physics ideas (problem solving) during microteaching.
GS7: Is able to write a unit plan that has all required elements.
GS8: Is able to solve (or explain why the solution is not possible) for any physics problem at the level of algebra-based physics in the areas that are addressed in the course.

Lesson Specific Standards (broken down into Content Standards – CK and Pedagogical Content Knowledge Standards – PCK)

Area of physics	CK	PCK
Geometrical optics	**CK-1 Can use real optical systems and ray diagrams to locate an image produced by a reasonable optical system, including glasses.**	**PCK- 1 Can design a rubric for self assessment of ray diagrams.**
Electric field	**CK-2 – Can use different graphical and mathematical representations of electric field to reason about electrostatic processes in a vacuum, dielectrics, and conductors.**	**PCK-2 Can show how help students write and use a rubric to self-assess their use of graphical representations of electric field (electric field vectors, electric field lines and equipotential surfaces).**
DC current	**CK-3 Can use analogies, microscopic models and physical quantities to reason about electric circuits including complex elements** **CK-4 Can solve complex electric circuit problems involving multiple loops, multiple batteries and batteries having internal resistance.**	**PCK-3 Can solve the same problem using analogies, microscopic models and physical quantities and explain what students will benefit from which approach.** **PCK-4 Can show a sequence of instructional moves to help students master the concepts of DC circuits using simulations.**
Magnetic field	**CK-5 Can use all graphical and mathematical representations of magnetic field to reason about magnetic processes in a vacuum, diamagnetics,**	**PCK-5 Can show how help students write and use a rubric to self-assess their use of graphical representations of magnetic field (magnetic field vectors and magnetic field lines).** **PCK-6 Can show how to engage students**

	paramagnetics and ferromagnetics. **CK-6 Can explain how to connect the concepts of electromagnetic field to communication industry**	**in solving practical problems involving electromagnetic fields**
Photon model of light	**CK-7 Can explain photoelectric effect using the photon model of light and energy bar charts.**	**PCK-7 Can show how to use simulations to help students learn about photoelectric effect.**
Mechanics	**CK-8 Can use motions diagrams, kinematics graphs, force diagrams and momentum and energy bar charts to analyze typical mechanics situations**	**PCK-8 Can describe in detail how to help students master the representations used in mechanics (see the column on the left) and how to use them to make a bridge from concrete phenomena to mathematics. Specifically can describe student ideas related to these representations and ways to help students learn.**

Academic Integrity Policy:
Any violation of academic honesty is a serious offense and is therefore subject to an appropriate penalty. Refer to http://academicintegrity.rutgers.edu/integrity.shtml for a full explanation of policies.

Course Requirements

Attendance Policy: You are expected to attend every class, however I understand that emergencies may arise. If you need to miss class for any reason, you need to email *prior* to the class that you are going to miss and let me know. We will then work out a mutual time for us to meet so that you can make up what you missed. Each unexcused absence will result in the lowering of your course grade by half a letter grade.

Summary of Requirements

Attendance, participation in class discussions: Attendance and participation in each class meeting are crucial for your learning. Discussions in class will focus on problem solving and research on student learning in a particular area.

Quizzes Every class will start with a quiz. A quiz will consist of a physics problem that you will need to solve and a set of questions regarding cognitive processes and student learning. If you wish to have more time for the quiz, please come to class early, I will be in the room at 4.30 pm. Every quiz can be improved.

Homework: Homework assignments will vary each week. All of them will address a specific standard. The homework is due Wednesday night by e-mail to Rob. The file should be labeled with your first name and week number: Kristen1.doc

2. Each week you will be given a reading assignment. It is your responsibility to read the papers and the chapters from 2 books. The material from assigned readings will be on the exam.

Micro Teaching: You will choose a topic for problem-solving lesson in class from the class schedule table (160 min). It will be a problem-solving lesson, not a concept construction lesson. You can choose any lesson format you want, creative ideas are welcome. It is very important that your lesson is based on student ideas, uses productive representations, engages the students in quantitative problem solving and shows connections to their lives (though technology, usefulness and applicability of ideas, etc). Please, plan your lesson in advance and submit the first draft 2 weeks prior to your teaching. You will need to submit a lesson plan after you teach the lesson (this is the plan that goes into your portfolio if you are in the teacher certification program). Make sure that the lesson addresses general standards GS1-6 and specific CK and PCK standards.

Unit plan and lesson plan: After you teach the lesson, you will write a unit plan for a unit where this representation is most heavily used. The unit plan together with the lesson plan will be shared with your classmates. The unit plans goes into your portfolio. Make sure that the unit addresses general standard GS7 listed for the course and specific for this unit CK and PCK standards.

Final exam: On the last day of class there will be an oral examination. You will receive a list of exam questions in advance. They will be posted on the class website. The exam will consist of a discussion with Rob on two of the questions (selected randomly) and problem solving.

FCI and CSEM: By the end of the course you must take and score a 90% on both the FCI and the CSEM assessments.

Tentative list of topics for discussions (by week)

Week	**Topic**	**Assignment (Ch)**
1	Using MR to understand complex phenomena. Types of MR. MR in problem solving.	Preface
2-4	Brain, memory, analogies and MR. MR in electric circuits; lesson 4 to **pick for teaching** – complex circuits with batteries having internal resistance	College Physics Ch. 17; ALG Ch. 17; PUM DC circuits module; Zull I Introduction Chapters 1-3
5-6	MR in geometrical optics; lesson 6 to **pick up for teaching** – glasses	College Physics Ch. 21-21; ALG Ch. 21-22. Zull I Chapters 4-6

		UBD chapters 6-10
8-9	MR in electric field; lesson 9 – capacitors **pick up for teaching**	College Physics Ch. 15; ALG Ch. 15; 24 PUM Electric field module Zull I chapters 10-14
10-11	MR in magnetism. Lesson 11 – projects in diamagnetism, paramagnetism and ferromagnetism, all participate	College Physics Ch 17, 18; 24 ALG Ch. 17-18, 24 Zull II chapters 1-3
12	Traditional physics assessments (FCI, MBT, CSEM, BEMA)	Zull II Ch.4-6
13-14	Multiple representations in modern physics (photoelectric effect and atomic structure)	College Physics Ch 26, 27; ALG Ch 26, 27 Zull II chapter 7-10
15.	Final exam.	