Can We Change Students' Beliefs about Physics?

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In traditional lecture courses courses usually calculus-base with large enrollments

& courses that use interactive engagement with large gains on the Force Concept Inventory (FCI) and other content surveys:

Students' scores on the Maryland Physics Expectations Survey (MPEX) and the Colorado Learning Attitudes about Science Survey (CLASS)] at the end of the course show that the students are *less* expert-like than they were at the beginning.

The normal alternative to a lecture-based classroom format is a single type of intervention.

Could an activity that gets students to examine textual material metacognitively (Reflective Writing) combined with one or more interactive interventions

help students change their approach to learning.

REFLECTIVE WRITING

When students arrive in class, they should be prepared to discuss the material that will be presented.

Simply reading the material in the textbook will not work.

They need to actually engage with the material in the textbook, trying to sort out what they understand and what they do not understand.

They should try and relate the concepts to ideas found in previous chapters and to their life experiences.

Instructions

Many of you may have experience that during discussion with others, you can clarify your ideas. Speaking to others is always helpful to obtain a better understanding. The idea of doing reflective writing is to construct a self-dialogue about what you have read. The main diffe
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The main difference between summary and reflective writing is that in a summary you write down what you already have in your mind during your reading, while in doing reflective
writing you question what you read and relate it to other concerns.

Instructions

Write down your own understanding of concepts, relationship among those concepts, or even relationship of the material to former chapters and your former knowledge from other disciplines and life experience.

jotting. Write down your own understanding of concepts, relationship among those concepts, or even relationship of the material to former chapters and your former knowledge from other disciplines and life experience.
Don’t worry if what you are writing is right or not. Marking is not based on that.

Marking criteria for reflective writing

Features present in the reflective-writing product	Meets criteria fully (100%)	Meets most of the criteria (65%)	Minimally meets the criterion (35%)	Does not meet criterion at all (0%)
Presenting the key concepts of the subject as understood by the student.	Complete -Does not copy the lesson.	Covers all concepts but not really in own words	Partial coverage of concepts	
Describing the relationship between the various concepts	-Qualitative interpretation used to compose the relationship in the words of the student. -	-Surface description of Qualitative interpretation used to compose the relationship . -	-Some attempt to compose the relationship .	Not able to interpret.
Student relates key concepts to his/her own life experiences	Shows clear understanding of how the concepts occur in everyday situations	Shows partial understanding of how the concepts occur in everyday situations	Mention of everyday situations without any explanation of how they relate to concepts under study in current sections	No relationships to his/her own life experiences are given.
Student formulates his/her own question(s).	Student realizes that there are concepts in the textbook that s/he does not understand and elaborates a clear question	Student sets out a question that is not clearly formulated	Student notes the difference between the students' own ideas and the versions found in the textbooks without any discussion	No questions given

First experiment: RW combine with in-class conceptual-conflict-collaborative group exercises and a critique writing activity which is basically an argumentative essay

C. [S.] Kalman, M. Milner-Bolotin, M. W. Aulls, E. S. Charles, G. U. Coban, B. [M.] Shore, T. Antimirova, , J. Kaur Magon, X. Huang, A. Ibrahim, X. Wang, G. Lee, R. L. Coelho, D. D. N. Tan, & G. Fu, **Understanding the nature of science and nonscientific modes of thinking in gateway science courses**. In M. F. Taşar (Ed.), Proceedings of the World Conference on Physics Education 2012 (pp. 1291-1299). Ankara, Turkey: Pegem Akademi. (ISBN:978-605-364-658-7), 2014.

We attempt to bring students to recognize that mechanics can be viewed as a coherent "framework".

A coherent framework is a highly ordered knowledge structure that embraces concepts, methods of applying concepts to solve problems, etc. It contains a coherent set of interrelated big ideas.

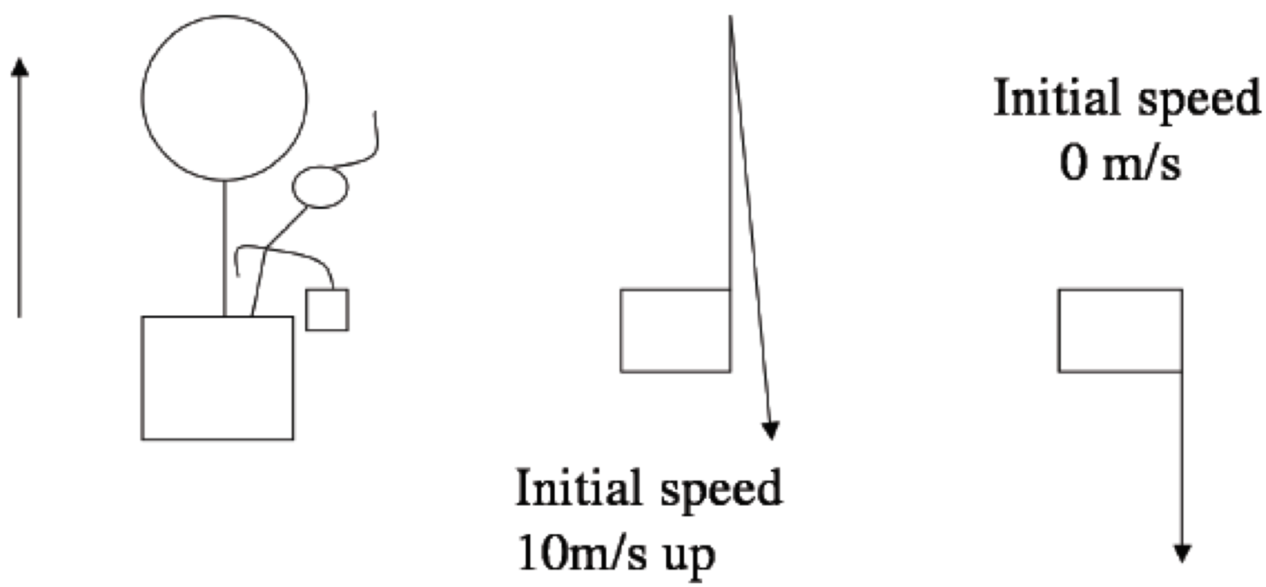
As students learn, they relate new material to the material that they feel they already understand and in the process accommodate the new material within the framework.

The in-class conceptual-conflict-collaborative group exercises were designed to provide students with a learning environment to question their alternative personal scientific conceptions and to expose them to other perspectives.

For example, in one of the exercises, students were asked to compare the motion of a free-falling body with a horizontal projectile. Then two groups of students were asked to present their ideas and to have other students question and challenge their proposed ideas.

Once students' perspectives are exposed to "public" scrutiny, their certainty about knowledge is questioned or reevaluated.

The critique writing activity is basically an argumentative essay, in which students have to put forward as many possible arguments in favor of all the conceptual viewpoints raised in class and then point out which viewpoint is correct from an experimental point of view.



At the left we see a sandbag being dropped from a balloon . (Give as many reasons as possible for each viewpoint.)

Critique#2–Suggested length 2 pages, but there is no page limit.

This investigation was conducted at two different institutions over a three-year period..

At Institution A, a comprehensive university, classes were relatively large sections (over 100 students each) of a typical calculus-based course in mechanics

At Institution B, a community college, there were relatively small classes (about 32 students each) of a typical algebra-based introductory course in mechanics, electricity, and magnetism.

The two institutions used different textbooks and had different formats.

All sections considered in this experiment at each institution were taught by the same instructor who was not part of the research team that authored this paper.

Was there epistemic change in students in the experimental group and control group after taking the course for one semester?

Before and after the intervention, the participants of both groups were asked to fill out the *Discipline-focused Epistemological Beliefs Questionnaire* (Hofer, 2000) adapted for the domain of physics.

We could only use data for those students who actually chose to fill out the questionnaire adapted for the domain of physics (DFEBQ) at the beginning and end of the course from the experimental group (n = 44) and control group (n = 15).

Our results indicated that students who experienced the full suite of activities become more expert-like after the one-semester intervention, beginning to see physics knowledge as interconnected and evolving, which can be better learned by relating the material to their prior knowledge and their life experience.

Students who experienced summary writing did not experience such a change.

The number of students was not enough to provide more than an indication that the suite of interventions would produce the desired result.

We therefore pursued our inquiry with a larger sample (212 students; 110 in an experimental group and 102 in a control group.)

In this experiment we followed reflective writing with an interactive intervention called labatorials.

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(2014-15) Sobhanzadeh Kalman Thompson Ibrahim & Wang

The name “labatorial” comes from a combination of “laboratory” and “tutorial”.

Students use a worksheet with conceptual questions, calculation problems, and instructions for the experiment and computer simulations

Labatorials highlight the physics concepts covered in lectures and encourage students to present and share their ideas with one another

Each labatorial worksheet starts with conceptual questions and then asks students to make predictions. After doing the experimental part, students need to explain whether their results support their prediction or not

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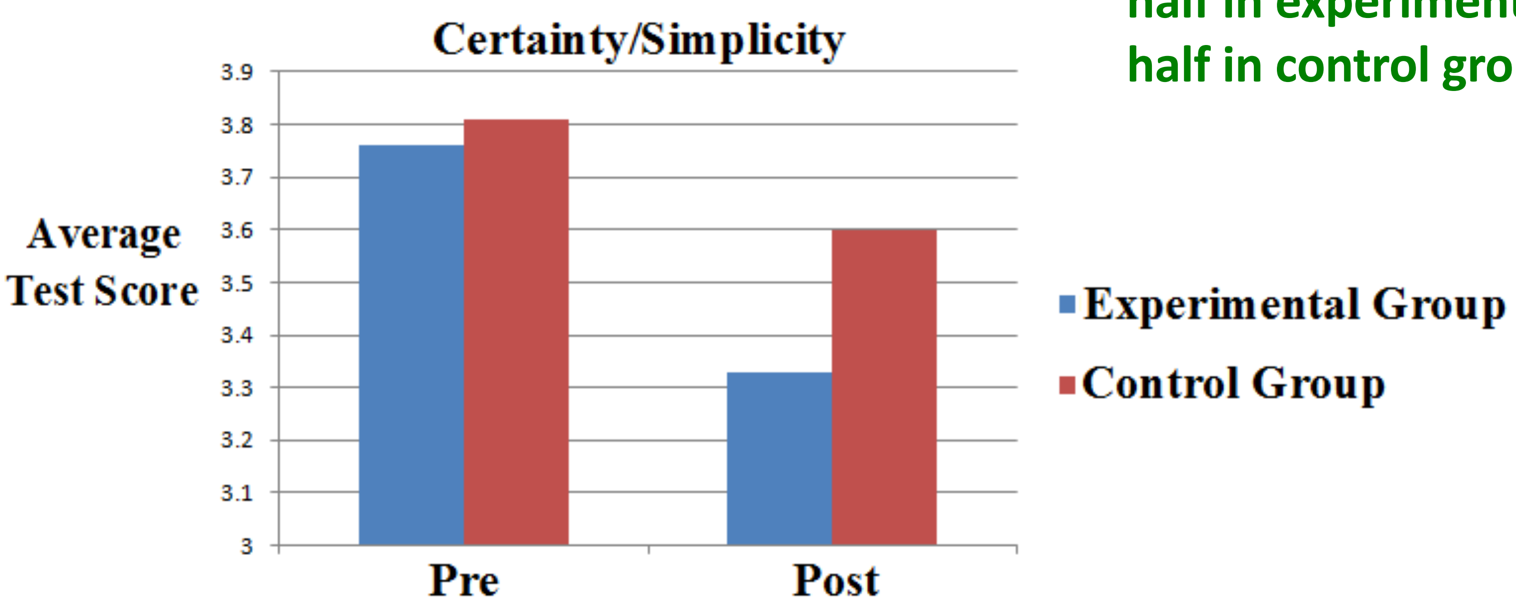
In labatorials, students complete a labatorial worksheet in groups of 3 or 4 students.

If the answer to a question is wrong or students are not proceeding in the right direction, the lab instructor leads the students to find the correct answer by themselves, exploring and discussing alternative ideas.

Epistemological results

Certainty/Simplicity:

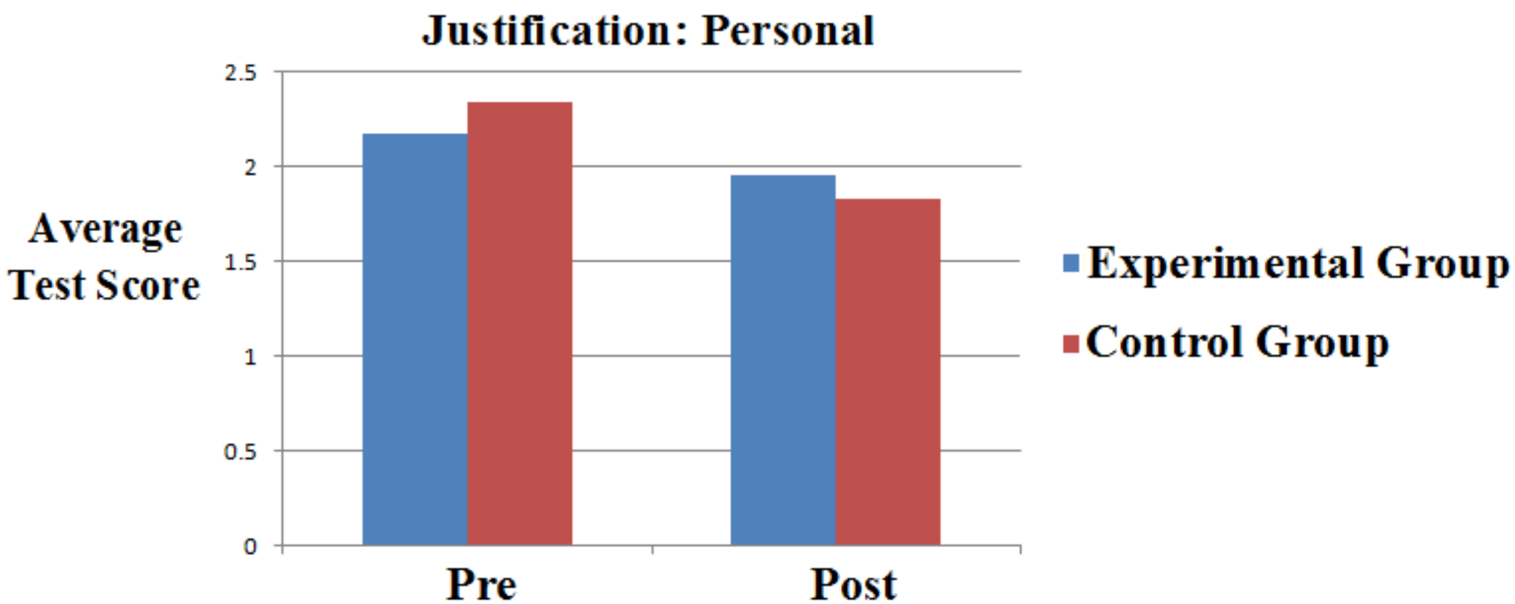
About 200 students
half in experimental group
half in control group



- There is an epistemological change in both control and experimental groups
- Change between experimental and control groups is significant

Epistemological results

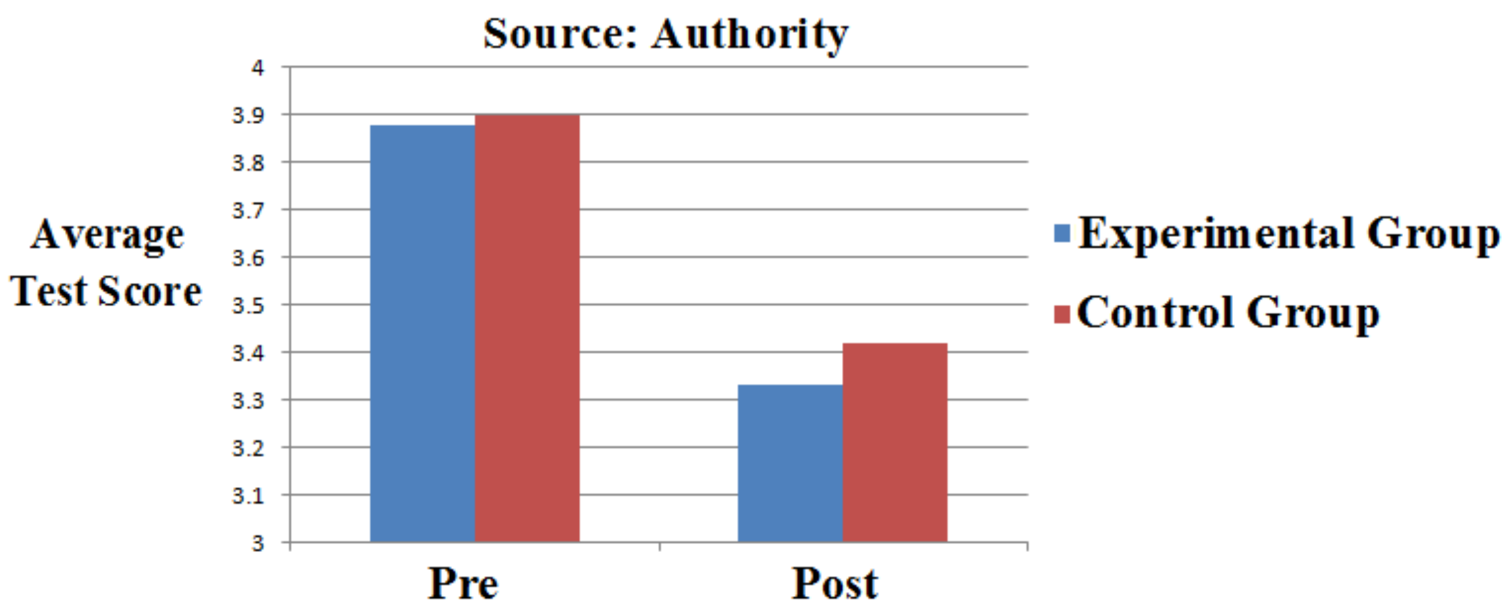
Justification: personal



- There is an epistemological change in opposite direction
- Change between experimental and control groups is significant

Epistemological results

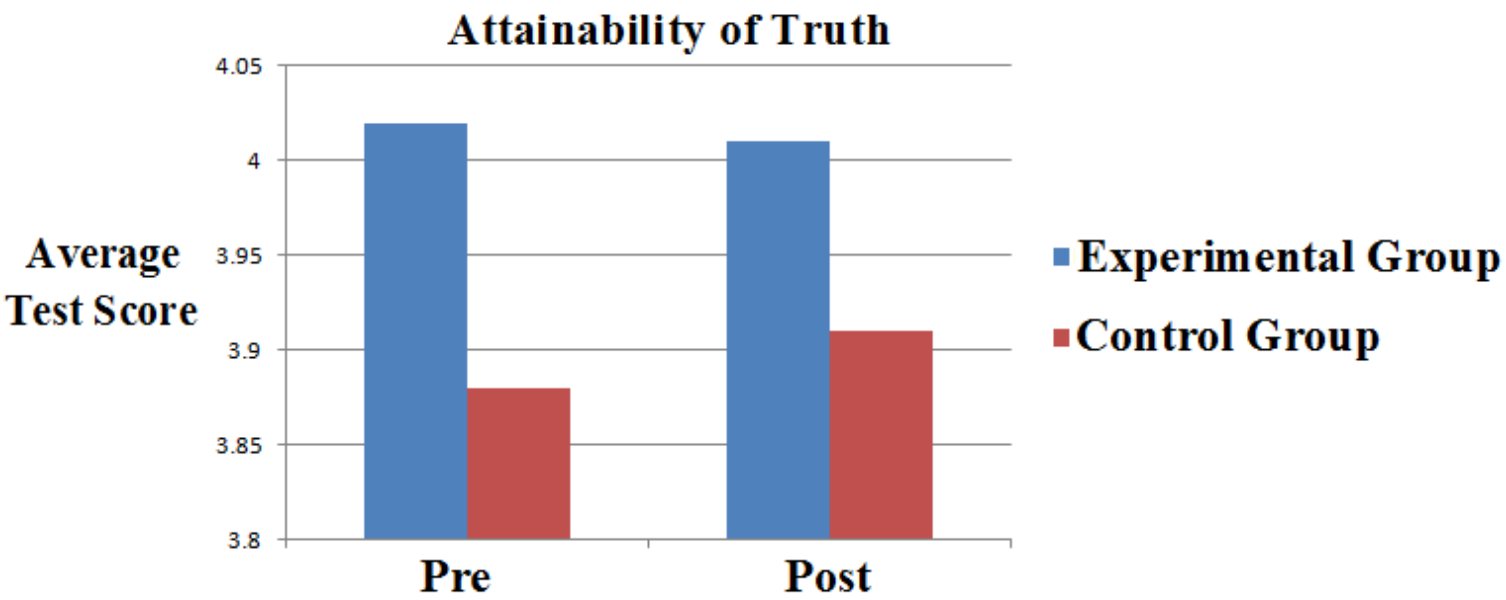
Source: Authority



- There is an epistemological change in both control and experimental groups
- Change between experimental and control group is not significant

Epistemological results

Attainability of truth



- There is no epistemological change in both control and experimental groups

In the DFEBQ, the four epistemic belief dimensions are Certainty/Simplicity, Justification of Beliefs, Source of Knowledge, and Attainability of Truth

The Certainty/Simplicity dimension represents individuals' beliefs about the nature of knowledge. The Certainty component of this dimension reflects whether individuals view knowledge as being absolute and certain or as tentative and evolving

The Simplicity component reflects whether individuals believes knowledge is accumulated bits of facts or is interconnected and context specific

The Justification of Beliefs dimension reflects a belief that knowledge is justified by relying on experts versus individual opinion and firsthand experience.

The Source of Knowledge dimension reflects beliefs that knowledge is handed down by an authority figure such as a teacher or other expert or it can be personally constructed.

Finally, the dimension Attainability of Truth reflects individuals' beliefs about whether ultimate truth is attainable.

Conclusions:

Administration of the *Discipline-Focused Epistemological Beliefs Questionnaire* showed that the novice science learners become more expert-like and saw knowledge as interconnected as a result of having participated in the intervention.

Analysis of the results based on the interview rubrics showed that that the students in the experimental group were able to identify concepts and relate them to previously studied concepts within the course and to their own life experiences.

They came to the realization that some ideas/facts/data presented in the textbook are in conflict with the students' own ideas.

Most of them were also successful in discussing the conflict.

Conclusions:

In the interviews, students typically stated that they were "thinking about some of the concepts we are taught for problem solving."

in the 2012 interventions when students stated that they viewed learning as "Seeing concepts from different perspectives" (five students) and "Seeing physics (or other knowledge) as more than a collection of facts, having a relational structure" (five students)

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Implications for Physics Teaching

Implementing the pedagogical strategies has the potential to help instructors in introductory physics courses to empower their students in learning science by learning how to learn.

It can help them move from template-driven to paradigm-driven thinking in the subject matter, even in gateway courses.

It can help them perform better. Moreover success in courses resulting from acquiring such strategies can help retain students beyond gateway courses in science.

It is important to use a combination of activities--the suite is more effective than any of the single activities on its own--and to make participation compulsory. The activities should be built into the evaluation system

Thanks!!