

# Similarities and Differences In Ideas Generated by Physics Learners: US College Students Vs. Tibetan Buddhist Monks

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**Abstract.** We have used PER-based course materials to teach various physics topics to Tibetan Buddhist monks over the last four years. While listening to the monks' ideas through interpreters, we found some striking similarities with ideas that we hear in our own classrooms in the US. However, the degree of similarity of monks' ideas with those of US students varied with the topic. For example, ideas that emerged in the topic of magnetism were often consistent with western ideas while ideas about color addition were sometimes strikingly different from ideas that American students use. The monks' ways of talking lead us to believe that cultural background partially determines how they think initially about particular physics topics. This poster will give examples of similarities and of differences, and attempt to identify reasons for both.

**Keywords:** Cultural differences, magnetism, color, Tibetans, curriculum materials

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## INTRODUCTION

One key to the success enjoyed by physics education research is attending to students' ideas and reasoning. PER is developing a base of knowledge about American students' preconceptions and problematic ways of thinking so that curriculum developers can create course materials that successfully address them [1]. However, little work has been done with students outside of the Western world - do they think in ways similar to western students? Can PER materials developed in the US be used successfully with members of other cultures?

We might expect students from non-western cultures to have different ideas about physics. Differences in educational background of non-US students compared to US students might result in different tacit knowledge and/or different gaps in knowledge than normally found in western students. Differences in culture could lead to ways of thinking or ideas about the nature of reality not normally found in western students. And finally, some cognitive scientists hold that culture strongly mediates cognition [2,3]. Therefore, before blindly assuming that the results of PER in the US will hold true everywhere, we should check.

However, when teaching physics via inquiry/guided experimentation, there are reasons to expect that students from non-western cultures should at least arrive at ideas that are similar to those of

western scientists. We believe that the physical world should behave the same regardless of the culture of the observer. Also, all humans have the same basic body and brain structure which influences how we interact with the world. And western culture is being disseminated worldwide. This investigation uncovered hints of the importance of this last phenomenon.

## THE SETTING

The Dalai Lama established in 2000 an annual month-long seminar in math and science - "The Science Workshop" for selected Tibetan Buddhist monks. This workshop brings together highly regarded monks from the many Tibetan monasteries-in-exile around India for classes in physics, astronomy, cognitive science, biology, and mathematics. The monks range in age from 25 to 45 and have achieved degrees in monastic studies roughly equivalent to MS or PhD degrees. The purpose of the workshop is to help the monks understand western science and to explore points of contact between Tibetan Buddhism and western science. One eventual goal is to introduce science teaching into the monastic curriculum.

A few members of the US PER community have been invited to teach physics to the monks: Stamatis Vokos, Rand Harrington, Hunter Close, Dewey Dykstra, Andy Johnson, Mel Sabella, Eleanor Close, and Ed Prather. The workshops on which this poster is

based were taught in January 2006 and January 2007.

We used inquiry based course materials to help the monks recognize the experimental and evidential basis of western science, and also to help the monks develop robust understandings of topics in physics from the western point of view. Working in small groups, the monks worked through guided inquiry activities using paper documents translated into Tibetan. Occasional whole class discussions were held in Tibetan, with translation by Tibetan school teachers. Topics over the last four years included image formation by lenses, heat & temperature, color addition, magnetism & magnetic materials, and waves & sound. It seemed to us that the courses worked reasonably well, suggesting the plausibility of using western course materials with eastern Buddhist students.

Nevertheless, we wondered about the feasibility of using western course materials with the monks. Two of our questions are:

1) When taught using translated PER-based materials and course structure, do Tibetan Buddhist monks arrive at understandings that are more or less similar to those of western students?

2) Do Tibetans have or develop ideas that are different from those we detect in western students? If so, can we identify the origins of these ideas? And how problematic are they for existing course materials?

We did not attempt to formally assess monks' thinking, but we kept our ears and eyes open and we collected as much data as was practical. This paper describes some issues noticed during lessons on Magnetism and on Color, which are detailed one at a time below.

## **OBSERVATIONS**

### **Teaching Magnetism To Monks**

We used the magnetism chapter from the Physics and Everyday Thinking (PET) materials in our work with the monks.

Some of the content goals of this unit are to discriminate between electricity and magnetism, to explain the unmagnetized and magnetized conditions of ferromagnets, and to explain magnetic attractions and repulsions in terms of magnetic-domain-like entities. The students in the course develop this model through experimentation and careful thinking in a guided inquiry setting.

### *Categorizing the Monks' Models:*

Throughout the magnetism unit, students are asked to describe their current thinking about what is in magnets or nails to cause magnetic effects. Model diagrams drawn by US students tend to fall into a set of "typical categories" that have been identified previously [4]. The monks' diagrams closely corresponded to the existing categories, and their prevalence at various stages in the unit closely matched those of US introductory physics students. The main difference is that their diagrams started out a little more advanced than is seen with some groups in the US. Table I shows the most common models at three stages in the unit - beginning, middle, and end.

### *Discussion*

The monks developed models along pathways that very closely followed what US students do! There is more variation in models and ideas at the beginning of the unit, and both US and Tibetan students proposed about the same variety of models with about the same frequencies. At the end of the unit, both groups of learners proposed models very closely aligned with the magnetic domain model.

Also, as we listened to (translations) of monks' conversations, we heard similar ideas to what we normally hear in the US. Therefore, we found no significant content difference in using the magnetism with monks versus using them with US students.

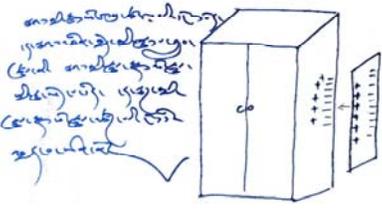
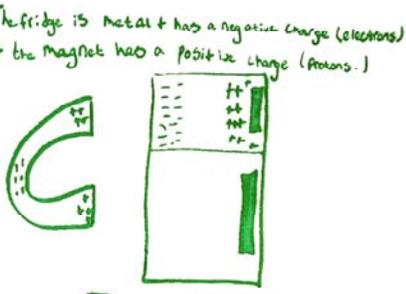
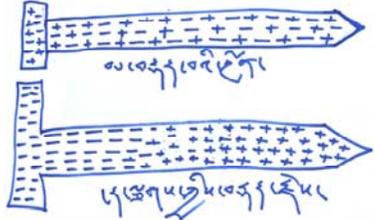
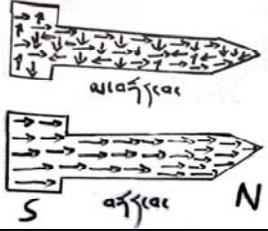
### **Teaching Color To Monks**

We used Cycle 4 of the CPU Light and Color unit with some modifications. Some content goals for the unit include discriminating between overlapping colors of light (color addition) and overlapping filters (color subtraction), and developing schemes (using RGB and CMY colors) to predict and make sense of the colors that result when two colors of light overlap on a white screen, when colors of light pass through colored filters, and predicting colors that are observed when colored surfaces are viewed under light of some other color.

### *The monks' ideas about color:*

As a result of instruction, the monks did develop the target ideas defined for the color unit on about the same timescale as US students. However, we heard the monks talking about two particular ideas that caught us by surprise.

**TABLE 1.** Diagrams For Magnetic Explanations Drawn By Monks And US College Students

Point In The Unit	Tibetan Buddhist Monks	US College Students
<p><b>Day 1 of Unit</b> (Explaining how a magnet sticks to a metal cabinet or refrigerator).</p>		<p>The fridge is metal + has a negative charge (electrons) + the magnet has a positive charge (protons.)</p> 
<p><b>Midpoint of Unit</b> (Explaining the two - ended behavior of a magnetized nail).</p>		
<p><b>Final Proposed Models</b> (Explaining all of the observed behaviors of magnetized and unmagnetized nails, including a cut nail).</p>		<p>Un-mag</p>  <p>Strongly Mag</p> 

At one point during the color unit, one of the monks engaged an instructor in a discussion involving a different line of reasoning about color addition. The monk was considering this question: "What color will you see when green and red filters are overlapped?" The monk described his reasoning this way: "All colors have characters of black and white. But green light has more of a white character than a black character. On the other hand, red light has more of a black character than a green character." The monk went on to use the white and black characters to infer a prediction about which color - red or green - would be more prevalent.

In making this prediction, the monk was considering only the colors and their properties, rather than thinking about light. American students do this too. However, none of us had ever heard anyone using reasoning about "black and white characters of colors". This idea was completely unknown to the western teachers before the workshop. We do not yet know how this line of reasoning affected the monks' success with the course, although they were able to use the western RGB model successfully.

In addition to their different reasoning about colors, the monks also have different ideas about light and darkness. The following description - or parts of it -

was repeated in different situations by a number of different monks. The Tibetans say that both light and darkness exist, but they compete or conflict with each other. Light is necessary to see objects, while darkness hides objects. Light is stronger during the daytime, while darkness is stronger during the nighttime. Shadows are not the same thing as darkness, because you can see things that are in shadow, while you can't see things that are in darkness.

When a Tibetan enters a dark room, she is likely to say, "The only thing I can see in here is darkness". (Darkness is something that can be seen). If a light is turned on in the room, the Tibetan might say "The light pushed the darkness back so I can now see some things." This idea of darkness-as-something was not fully addressed by the course materials and was left unresolved.

The monks were particularly interested in the study of color from a western point of view because the observation of a color is a phenomenon at the boundary between the world and the mind. The monks are interested in perception. Therefore, at the conclusion of the color unit, the monks pressed multiple science professors to explain to them the western answer to these questions: "If I look at a colored object, where is the color? Is it in the light

that strikes the object? Or is it in the object itself? Or is it in the light that travels from the object to me? Or is it in my mind?" They may have just wanted to try to put the western professors into an epistemological tight spot for fun.

#### *Discussion:*

Tibetan monks have some different ideas about light and color that are not observed in western classrooms! This might be explained by their different cultural backgrounds.

For example, Tibetans have a different system of colors from the RGB/CMYK system used in the West. The first level of Tibetan teachings, (the Vaibhasika dharma) focuses on objective description and explanation of physical phenomena. It describes root colors and branch colors:

Root colors: (Tibetan primaries): blue, yellow, white, red

Branch colors: (Tibetan secondaries): clouds, smoke, atoms, dusk/twilight, darkness, shadow, color of sunlight and rainbows, ngangwa (not readily translatable).

Also, when Tibetan Buddhist monks begin debating, their first topic is colors. As a result, Tibetan Buddhist monks are well versed in traditional Tibetan ideas and arguments about color. While we did not find out, it is possible that the "white and black characteristics" notion is probably taught in the monasteries.

In teaching color to the monks, we inadvertently encountered cultural background knowledge that was well-developed prior to the Science Workshop for Monks. However, the monks did resolve the main questions of the course and the resulting "formally accepted ideas" proposed by the monks were very similar to ideas that US students propose.

Unlike the case for color, the monks had not been taught extensively about magnetism in the monasteries. Over previous years in the workshop they received many lectures on physics (not given by any of the PER members listed above)! It is quite likely that most of the monks had heard about electric charges, and a few had been told about magnetic domains. The monks apparently tried to press these ideas into service during the magnetism unit, with results similar to what we see in the US.

It is likely that more than a handful of monks had been lectured to about magnetic domains but based on our observations in the class, very few or none of the monks understood how to sensibly use the ideas of magnetic domains about which they had been told. This adds support to the claim that lectures to any group - even highly regarded Tibetan Buddhist monks,

and even by highly regarded physicists - does not support meaningful physics learning.

## CONCLUSIONS

We can now offer tentative answers to our questions:

Q1) Do Tibetan Buddhist monks arrive at understandings that are more or less similar to those of western students?

A1) It appears so. But this has yet to be studied in detail. And prior to reaching the target ideas, the monks may take other pathways.

Q2) Do Tibetans have or develop ideas that are different from those we detect in western students?

A2) It depends on previous learning experiences. Tibetan Buddhist monks have not been taught extensively about magnetism in the monasteries, and they therefore attempt to use what has previously been presented to them in lectures. However, because of the cultural importance of specific color reasoning in the Tibetan Buddhist monasteries, monks do reason significantly differently about theoretical aspects of color addition, at least until they study color using western course materials.

The ideas about black and white character of colors, and darkness as "something", originate in traditional Tibetan teachings and Tibetan culture. We do not have evidence to say whether existing course materials are sufficient to ensure that the majority of monks will switch to and use a new view of light and color. In fact, we may not want the monks to abandon their old ideas about light and color as our purpose for the science workshops was to introduce the monks to western types of reasoning and sense-making, not to indoctrinate the monks into a new way of thinking.

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