# Thinking through images: the varied roles of visuals in undergraduate learning in the Earth sciences and beyond

## Anna Maria Ryan[1]

### Abstract

*Students come to our undergraduate classrooms typically fluent in text-reading, but less so in reading images, videos, graphs, and maps for scientific meaning. In a discipline such as the Earth sciences where nature is the first "laboratory" and observation is a critical skill, we can be literally at a loss for words in describing what we see – it is not unusual for an Earth scientist to draw what they see in order to describe and interpret. However, weather, systemic structures, cost, logistics, and a host of other considerations mean that we cannot always teach in the field. The use of visuals in our teaching is one way in which we can get a little closer to the field experience, but if students fail to see and understand what we expect them to see and understand from a given visual, then the image is simply a nice picture or drawing, and not a valuable teaching tool. Visuals used wisely can serve to bring the global into the classroom, stimulate discussion, and broaden perspectives, in addition to clarifying a concept. How do we help students develop their ability to "read" images, diagrams, graphs, maps, and videos so they better understand the concepts and ideas? Are there threshold concepts involved in learning to read a visual as experts read such visuals? And how can we encourage students to develop their own use of images to communicate the science effectively? Modern technologies mean students can photograph and describe features to demonstrate their understanding; they can use images to support text in infographics; images can be discussion starters for new concepts or ideas, or they can serve to summarize and synthesize their learning. This session explores the use of visuals from two perspectives: (1) as an effective teaching tool for a variety of topics within the Earth sciences and beyond to students at all undergraduate levels; and (2) student use of visuals as an engaging way for them to convey their understanding, as well as a means of bringing the outside world into their classroom learning.*

**Keywords**: *visuals, science, undergraduate education, learning, threshold concepts;*

## 1.Introduction

In recent years, introductory textbooks in the earth and environmental sciences and beyond have almost equal space devoted to visuals as to text. These typically coloured visuals range from photos, through schematics, to graphs, maps, and 3-D imagery, and are intended as pedagogical aids, and are potentially a rich source of learning that our students often overlook. "Reading" the imagery requires that students develop visual literacy, the ability to read and interpret a variety of visuals, as well as the ability to use visuals to communicate meaning [1 and 2]. Communication through visuals offers an alternate means to convey ideas: many of us have been in distant countries where universal symbols and images allow us to find our way around airports and other public arenas, in any language. Yet we rarely help students develop skills in reading and interpreting images within our disciplines, or in the power of creating them as a means to better understand and communicate ideas. Are we therefore depriving them of a means to understand and to communicate their discipline more effectively?  Creating a visual, whether digitally or on paper, serves to slow the student down, and allows them to think about what they are trying to represent in a new way. Reading a visual similarly opens up an idea more completely: often serving to synthesize a concept more holistically than words alone. Bamford [3] proposes that, to be an effective communicator today, "… a person needs to be able to interpret, create, and select images to convey a range of meanings." (p.1)

## 2. Reading and communicating with visuals: the importance of practice

If an image is to become more than a nice picture, students need to know how to read and interpret such images. To do this requires effective practice. Indeed, Willingham [4] argues for the importance of practice that involves ongoing use of a strategy. Similarly, Felten [5] argues that students need us to deliberately

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[1] Dalhousie University, Canada
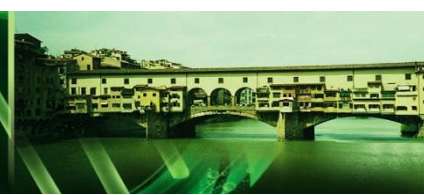
work with visuals as they develop what Ausburn and Ausburn [6] refer to as "higher-order visual literacy". In other words, we should be questioning students about images and discussing what they see, what they don't see, and what they think it means and we need to engage them in creating images. In our teaching, instead of using words only, we need to use a combination of images and text; instead of telling students what they see, we need to ask them; and instead of making everything we discuss during class available online or as perfect images, we need to allow them time to draw and represent features, concepts and ideas. We ourselves also need to draw, either on a board or digitally, and talk through what we are doing as we proceed. When we do this, students start to see our thought processes, and can begin to think in the discipline.

Among the uses of images that cause particular difficulty for students, are the reading of graphs, or representation of information graphically, especially in the early undergraduate years. When I think back on my own learning about graphing, I do not remember having difficulty, or what it was to not be able to graph or read a graph. It is possible that reading graphs expertly is a threshold concept [5]: one which is transformative, integrative, troublesome, irreversible, and bounded. In other words, once students master graph reading and production, their perspective of the material is changed, their understanding deepened, and it is unlikely they can unlearn the processes involved. Meyer and Land [5] describe this transformation stage as akin to travelling through a portal, or a liminal stage, and typically a troublesome process. Such threshold concepts are notoriously difficult to teach, as they require students to go through this stage of discomfort: this is certainly true in many students' journey to graphing mastery. Similarly, reading and creating geologic maps pose a new challenge for students, yet once mastered, provide new insights and understandings. Again, critical to developing this mastery either in graphing or map reading, is opportunity for extensive and effective practice, but coupled with support and acknowledgment that the learning process may prove challenging, and that some frustration is common. In other words, we lead here by being supportive guides on the side as students move through this stage.

## 3. Specific Strategies To Develop Visual Literacy

We can build on these ideas with a number of specific strategies that engage students actively in making meaning through the use of visuals, both in terms of reading images, and in terms of creating visuals. The selection that follows are all strategies I have adopted in various courses some of which are expanded upon in Ryan [8]. Feedback from students, as well as the evidence in the work produced, suggests that these are useful tools for developing visual literacy.

### 3.1 Images as discussion starters

Students come into our classes with the minds in a million different places. Beginning a class session with an image and a related question relevant to the content-of-the-day, serves to focus students' thinking, and awakens their interest. This image might be related to something in the news, a photograph of a place or feature relevant to the topic at hand, or a diagram, graph, or map that serves to review the previous session – perhaps with labels removed, so students can fill in the information. This valuable class-starter takes just a minute or two, but with the focus now on the content at hand.

### 3.2 Images as summaries of learning

Inviting the students to find an image, draw an image, diagram, or graph to show their understanding of the material from a given class, serves as an effective means to end a class. Collecting these images for a quick scan further provides insights into understandings and misconceptions.

### 3.3 Image labeling and identification – in class, and in testing

By way of quick review, giving students diagrams without labels and asking them to label appropriately serves as a quick test of their ability to identify features, and sometimes conceptualize problems, depending on the nature of a given diagram. It is also useful for us to create questions rather than descriptions to go along with powerpoint slides of photographs, graphs, diagrams, and maps, so students actively engage with the image, rather than passively await your description of what they are supposed to see.

I regularly use powerpoint images of all sorts as a means to test student understanding, both during class and during quizzes and exams.

### 3.4 Photography

Almost every student has a camera phone, so having students take photos "in the real world" is both a useful evaluation tool and a fun exercise that creates opportunities for students to take their learning outside the classroom and observe. Students consistently report that they thoroughly enjoy this exercise and that they start to see the earth around them they had not seen before.

### 3.5 Collect data, and draw a graph

There are many opportunities for students to collect data (or be given a set of data), and be required to represent these data in graph form. Such an exercise requires students critically think about the data, select the optimum way to represent it graphically, and communicate their graphic representation effectively. Not only does this give students practice in data collection, analysis, and synthesis, it also gives us windows into their thinking, and into possible misconceptions and uncertainties that exist.

### 3.6 Creat an Infographic, Photo Essay, Poster

We are bombarded with images and bite-sized communcations. Engaging students in creating some of these bite-sized communications for an audience outside their instructor, forces students to consider the needs of the audience, how to effectively get a message across in a meaningful and interesting way, and to demonstrate their understanding of a given concept or idea. Again, this demands higher order thinking, as students have to consider multiple aspects, including what to omit as well as what to include and how best to include it.

### 3.7 Creating images to represent a concept – peer evaluation

Students will tell us that when they have to share their work with their peers for feedback, they complete it to a higher standard: like us, the opinions of their peers matter. Inviting students to complete a representation of a particular concept or idea from an article, which they then share with their peers for critque, provides a useful and interesting exchange of what a meaningful image is, and can or cannot do.

## 4. Conclusion

When used wisely, images in teaching and in learning create opportunities for students to more actively engage in the learning, deepen their understanding, and generate new insights; critical thinking is enhanced, and interest is increased. Is this not what we all want for our students?

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