Exemplification in Undergraduate Biology: Dominant Images and Their Impact on Student Acquisition of Conceptual Knowledge

Alandeom W. Oliveira, Erin Johnston & Adam Oliver Brown

Canadian Journal of Science, Mathematics and Technology Education

ISSN 1492-6156

Can J Sci Math Techn
DOI 10.1007/s42330-018-0017-0

Springer

Can J Sci Math Techn
https://doi.org/10.1007/s42330-018-0017-0

Exemplification in Undergraduate Biology: Dominant Images and Their Impact on Student Acquisition of Conceptual Knowledge

Alandeom W. Oliveira · Erin Johnston · Adam Oliver Brown

Abstract Striving to better understand exemplification, this study examines the types of animal behavior references (anthropomorphic/non-anthropomorphic) and taxonomic groups featured in the examples given by an undergraduate biology instructor during a semester-long course. It is reported that instruction was dominated by anthropomorphic examples of mammals and birds. Further, these dominant examples were found to bias the conceptual knowledge acquired by students who showed a tendency to conceive of nonhuman conduct in terms of mammalian and avian action. It is argued that extending biological exemplification practices beyond mammals and birds is essential to help students develop deep conceptual knowledge and an unbiased appreciation of life.

Résumé Afin de mieux comprendre l'exemplification, cette étude analyse les types de références au comportement animal (anthropomorphique/non anthropomorphique) et aux groupes taxonomiques qui figurent dans les exemples donnés par un enseignant de biologie au premier cycle dans un cours semestriel à l'université. Il semble que les exemples anthropomorphiques sur les mammifères et les oiseaux dominent cet enseignement. De plus, les exemples dominants ont pour résultat d'influencer les connaissances conceptuelles acquises par les étudiants, qui tendent à concevoir les comportements non humains en termes de références aux mammifères et aux oiseaux. Nous estimons que le fait d'étendre les pratiques d'exemplification biologique au-delà des mammifères et des oiseaux est. essentiel pour aider les étudiants à développer des connaissances conceptuelles profondes ainsi qu'une appréciation non partiale de la vie.

A. W. Oliveira (✉)
Educational Theory and Practice Department, State University of New York, 1400 Washington Ave., ED 113B, Albany, NY 12222, USA
e-mail: aoliveira@albany.edu

E. Johnston · A. O. Brown
Department of Biology, Faculty of Science, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada

A. O. Brown
e-mail: abrown@uottawa.ca

A. O. Brown
Faculty of Education, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada

Published online: 29 June 2018

Keywords Biology examples · Animal behavior · Undergraduate biology · Dominant images

"Examples make visible, place before the eyes, illustrate what is meant" (Waldenfels 2015; p. 37)

Instructor exemplification—the practice of giving examples—is generally accepted as being beneficial to science learners. As concrete instantiations of abstract generalities, examples are commonly given by science instructors in an effort to illustrate theoretical principles, explain difficult concepts, and clarify complicated procedures and analyses (Bills et al. 2006). However, the pedagogical value of exemplification goes beyond didactic illustration of general concepts. Provision of examples is central to the processes of concept formation, concept acquisition, and concept learning (Oliveira and Brown 2016; Ormrod 2012; Tsamir et al. 2008). When varied and carefully given, an instructor's examples can give rise to student acquisition of deeper conceptual knowledge. As a result of being given examples, students develop fuller and more representative mental prototypes (mental images) that capture the typical/essential features of a wider range of cases within a given conceptual category.

This inductive process is symbolically depicted on Fig. 1a which shows how exposure to multiple examples of trees leads to the construction of a mental prototype wherein the notion of a "tree" is mentally represented as a biological category whose members share essential architectural features such as an elliptical crown at the top and a trunk on the bottom (Fig. 1a). This more general concept image captures only the defining features of trees while taking into account a certain degree of variability among specific species of trees (various crown shapes, diversity of trunks types etc.). Alternatively, students may develop biased mental prototypes when given examples that are predominantly or exclusively of trees with cone-shaped crowns and straight trunks (Fig. 1b). In such a hypothetical situation, tree is mentally constructed as a biological category that is necessarily conoid and branchless. These are defining features rather than possible features of trees (variation in shape is precluded). This dominant example gives rise to a conceptualization that is biased to a particular type of tree. The more recurrent this dominant example is, the stronger the mental association of tree with these two biological features. Persistent reinforcement leads to high mental salience, thus creating a tendency among students to conceive of trees in this conical manner.

Despite its potential to facilitate student acquisition of conceptual knowledge, instructor exemplification is often biased. Watson and Mason (2005) describe how classroom instruction is frequently dominated by classic examples (hereby referred to as "dominant examples"). Handed down from generation to

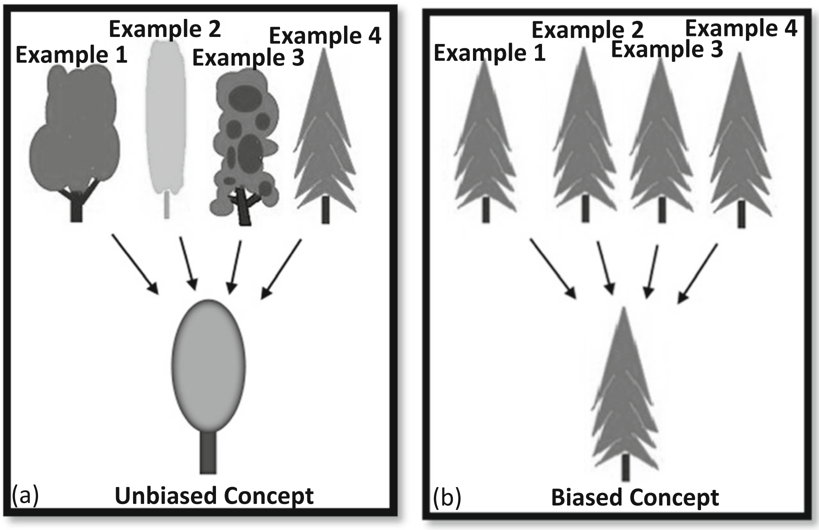

Fig. 1 **a** Varied examples giving rise to an unbiased "tree" concept and **b** dominant example leading to a biased "tree" concept

generation, these examples are recurrently used by instructors of a discipline to the extent of becoming "icons for concepts"—they come to stand for and constitute the associated concept. In the biology curriculum, previously documented dominant images include AIDS examples involving homosexuals that foster biased concept images of AIDS as a "gay disease" (Snyder and Broadway 2004), and examples of human macro-evolution that tend to overshadow micro-evolutionary changes in other organisms such as bacteria (Cook 2009).

As a result of overuse, recurrent examples become dominant mental images. They are the first and often the only thing that comes to students' minds when prompted about a particular concept, hence biasing students' mental activity and constraining their conceptual understandings. This is problematic since understanding a concept typically requires reflective consideration of multiple examples beyond the obvious. As Halmos (1983) writes, "a good stock of examples, as large as possible, is indispensable for a thorough understanding of any concept" (p. 63). To inductively construct a concept, learners need opportunity to make sense of a diverse range of cases, including boundary examples (unexpected and unusual), and sometimes even non-examples and counter-examples.

The occurrence of dominant images specifically in animal biology instruction has also been previously documented. Previous studies report that instructional materials commonly used for K-12 biology instruction favor large, exotic, charismatic fauna (e.g., Polar Bears, elephants, giraffes), often to the exclusion of controversial and unpopular species such as snakes and spiders (Magntorn and Helldén 2007; Yen et al. 2007; Randler 2008; Ballouard et al. 2011). Further, exposure to this biased biology curriculum limits students' knowledge about biodiversity and appreciation for the complexity and diversity of life (Lindemann-Matthies 2005; Huxham et al. 2006; Dove 2011; Celis-Diez et al. 2016). As a result, students are more likely to notice, identify, and be interested in exotic megafauna than in smaller, local animals such as insects in their own backyards.

While the occurrence and impact of dominant exemplification on students have been well documented at the K-12 school level, educational researchers are yet to determine whether and to what extent similar patterns can be also found in undergraduate science teaching. The present study attends to this limitation in the scholarly literature by examining the types of behavior references (anthropomorphic/non-anthropomorphic) and taxonomic groups featured in the examples given by a biology instructor during an undergraduate course on animal behavior. Additionally, we seek to assess the degree to which the conceptual knowledge acquired by the students may become biased toward dominant taxonomic groups.

Research Questions

Our research efforts are framed by following questions:

1. To what extent are the examples of animal behavior given by an undergraduate biology instructor dominated by particular taxonomic groups (mammals, birds, arthropods, fish, reptiles, and amphibians) and types of behavior references?
2. To what degree does the conceptual knowledge acquired by students become biased toward dominant taxonomic groups?

K-12 as an Indicator for University-Level Biology

Our review of the existing science education literature revealed a dearth of research on university-level biology. Like other educational scholars whose research interests lie above the K-12 grade level, we were faced with the difficult challenge of situating our inquiry in a field of scholarship that is relatively underdeveloped. This is made particularly clear in the national report *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering* (National Research Council 2012), which was recently published in the USA. The report describes how only 200 studies of university biology courses were published from 1990 to 2010 (83% since the year 2000), showing that undergraduate biology education research is still a relatively new and small field of inquiry. Moreover, much of this research was driven by general questions such as the overall value and effectiveness of lectures, leading the committee to make the following call for research:

> The emphasis of research on instructional strategies should shift to examine more nuanced aspects of instruction. The [previous] research on [undergraduate] instruction… demonstrates that student-centered learning can be more effective than traditional lecture. Now, a more nuanced view of instructional strategies is needed to advance knowledge of student learning in the sciences and engineering (p. 200)

This is precisely what we set out to accomplish in this study by focusing specifically on examples of animal behavior in an undergraduate course. Because this important aspect of behavioral biology instruction is yet to be examined at the undergraduate level, we use previous research at the K-12 schooling as an indicator for the sorts of teaching/learning phenomena that might extend to undergraduate biology education. We recognize that there are considerable developmental differences between these student populations in terms of cognition, maturity, attitude, etc. As novices and adults being apprenticed into a field of professional expertise, university students' ability levels, predispositions, and learning needs may different considerably from those of school-aged children. Nonetheless, this is the best empirical basis available to us at present. This body of work is reviewed in the following two sections.

Learning about Animal Behavior

Among those who have sought to examine what and how K-12 students learn about animal behavior is Bednekoff (2005) who provides an extensive curriculum analysis of school biology textbooks. Based on this analysis, Bednekoff (2005) identifies the five *essential topics of animal behavior studies*, namely (1) communication; (2) migration; (3) territories, competition, and dominance; (4) mating and sexual selection; and, (5) social behavior, altruism, and kin selection. Generally covered in this particular order, these larger categories of behavior identify the basic types of animal action studied by behavioral biologists. They constitute the most fundamental things that most animals do (Bednekoff 2005). Behavioral biology instruction seeks to help learners scientifically grasp these fundamental ways that animals behave.

However, it is well documented in the existing literature that learning to scientifically interpret animal behavior is far from simple. One particularly problematic aspect of acquiring the ability to explain what animals do is related to K-12 students' favoring of anthropomorphic or personified attributions that are often inconsistent with the scientific cannon (Coley et al. 2002). There is a tendency among students, especially younger ones, to project human qualities onto animals and to interpret their actions in terms of human-like mental states such as desires, beliefs, and intentions (Gopnik and Meltzoff 1998; Tomasello 2000). For instance, children have been shown to conceive of bird behaviors such as the crowing by Cocks in the morning and the picking of grubs from trees by Woodpeckers as being driven by the intent to wake up people and to rid trees of their pests, respectively (Prokop et al. 2007). Likewise, adolescents often view sharks as animals that are "intolerant of humans" and engage in human-targeted attacks (das Neves and Monteiro 2014), instead of responding to instinctive behaviors to hunt and kill for food. Students have also been shown to morally judge animal behavior based on considerations of human values such as justice, fairness, and welfare (Kahn 1999; Turiel 1998). Underlying these problematic tendencies of anthropomorphism and personification are misconceptions of animals as beings endowed with human-like capacity of intentional behavior and free will.

Empirical examinations of K-12 classroom instruction have revealed similar patterns in teachers' pedagogical practices (Kallery and Psillos 2004; Orlander 2016). Despite their expressed concern that anthropomorphism may confuse students and their efforts to avoid it, early-year teachers make extensive use of anthropomorphic metaphors, often without realizing it. Anthropomorphism is said to be so deeply embedded in teachers' knowledge (content and pedagogical) that they end up using it spontaneously and unconsciously. Explaining what animals do in terms of human capabilities such as feelings and desires is as intuitive for teachers as it is for students.

Taxonomic Choice and Behavior Reference

A fundamental aspect of giving examples of animal behavior is the instructor's taxonomic choice. When a biology instructor provides an example of animal behavior to illustrate a biological generality, s/he selects a particular kind of agent (an animal) who instinctively reacts to its natural environment (behaves) in biologically advantageous ways that have evolved over long periods of time (Alcock 2013). More specifically, the instructor chooses a particular species from one of many taxonomic groups, and then presents it as an actor whose performance inductively instantiates a given essential phenomenon of animal behavior (i.e., a case representative of what many animals do in a similar ecological context). As such, instructor exemplification of animal behavior constitutes a pedagogical practice characterized by taxonomic choices made in the context of inductive attribution of biological agency to animals.

A second important aspect is behavior reference. In addition to choosing a taxonomic group, the instructor also selects a particular way of referring to the specific behavior under consideration. As mentioned in the previous section, biology instructors can refer to nonhuman behavioral action either anthropomorphically or non-anthropomorphically. How an animal behaves can be described as action intended at accomplishing a particular goal or instinctive action devoid of human-like intentionality. Whether made in advance or impromptu, these choices eventually lead to design and public delivery of examples with the following two-part structure:

$$[\text{Species Name}] \quad + [\text{Behaviour Reference}]$$

Over time, the favoring of a particular taxonomic group or type of behavior reference by biology instructors can give rise to dominant images of animal behavior. As previous research has shown, certain types of examples can be more readily retrieved from memory than others due to frequency of exposure (Busselle and Shrum 2003). Because they stand out in our memory, these examples can bias subsequent mental activity by triggering cognitive processes such as the association of features to particular cases, recall of similar situations, and priming of heuristics or mental constructs for interpreting larger phenomena (Zillman 1999; Zillman and Brosius 2000). These kinds of studies underscore the possibility of dominant examples becoming more memorable to undergraduate students as a result of recurrent pedagogical exposure.

When drawn together, the above literature indicates the possibility of dominance in undergraduate biology exemplification. As in K-12 schools, the examples given in undergraduate biology may be unevenly distributed across taxonomic groups and behavior references, and hence potentially constitute a source of mental bias for students. As posited by the Salience Theory of Learning in the field of psychology (Rumbaugh et al. 2012), learners attend more closely to the most salient events in their perceptual environments (the most intense sources of perceptual stimuli). Further, environmental salience leads to mental salience or biased thought in the form of strong association links, easy recollection, etc. In the specific context of a biology lecture hall, salience of mammal and bird examples can serve as a source of perceptual stimuli with potential to foster a tendency among students to conceive of nonhuman conduct in terms of mammalian and avian action (a propensity to associate nonhuman behaviors with mammals and birds more than other taxonomic groups). The methodological approach taken to examine this possibility is outlined next.

Methodology

The present study adopts a mixed-method research approach (Bogdan and Biklen 2003; Creswell 2003), relying mainly on descriptive data collected through open-ended research methods such as video-recordings and surveys, which were systematically analyzed to build a naturalistic account (Lincoln and Guba 1985) of a biology instructor's exemplification practices. Such a methodological approach is reflective of our intention to gain a deeper insight into a pedagogical practice that is relatively understudied and under-theorized rather than to make universally generalizable claims. By simultaneous quantifying and qualifying instructor use of examples, we sought to systematically compare without reducing this highly nuanced practice to decontextualized numbers. Inclusion of a qualitative component allowed our analysis to go beyond simply reporting frequencies. Qualitative data served as a window into the classroom practice, allowing us to more clearly depict what in fact took place in the class when examples were given by the instructor and to most precisely document the educational processes/phenomena that gave rise to the reported frequencies. As previous research has shown, whether a particular examples stands out in one's memory depends not only on the frequency of its occurrence but also on other factors such as the presence or absence of attention-drawing features such as emotion-evoking imagery, high levels of realism and detail, and focus on unusual or extreme instances with a high degree of distinctiveness (Zillman and Brosius 2000; Busselle and Shrum 2003). In other words, the qualitative attributes of examples matter in addition to the nature of the content, as they may serve to enhance perceptual stimuli with relatively higher intensities or qualities.

Participants and Setting

Participants in this study were a group of undergraduate students taking a third-year biology course on the topic of animal behavior. Enrollment consisted of a total of 78 students (58 females, 20 males) mostly in their early twenties. The majority was Anglo-Canadian with a minority of Franco-Ontarians. The course was taught by the third author, a seasoned professor with a Ph.D. degree in biology and approximately 13 years of teaching experience at the university level, whom as a participant-researcher with an emic perspective as a social insider helped to enhance the validity of our etic interpretations (Bernard 2002). Our selection of this particular classroom setting was motivated mainly by the exemplification-based instructional approach that pervaded the course. Selecting a research site where examples were used extensively served to ensure that data on our phenomenon of interest would indeed be available for collection and analysis.

Aimed at introducing students majoring in biology to the scientific study of animal behavior, this 13-week course focused primarily on the ecological and evolutionary causes and consequences of a variety of animal behaviors such as communication, altruism and sociality, territoriality, aggression, feeding habits, mating systems, and parental care. The course met twice a week for approximately 1.5 h. During these meetings, Author 3 used PowerPoint slideshows and video-clips to engage students in the discussion of examples of animal behavior, in such a way as to develop students' logical reasoning skills, enhance their knowledge of scientific methodology and data analysis (Oliveira and Brown 2016). Structured as *concept formation lessons* (Parker 1988, 2011), students engaged deeply with sets of related examples as they were guided by the instructor.

During these concept formation lessons, examples were used to support student inductive construction of generalities central to the field of behavioral biology. Concept formation lessons are structured quite differently from more traditional frontal teaching (Parker 1988). In traditional lessons, the instructor first presents a definition of a concept and then cites examples that clearly fit their authoritatively stated definition. The conceptual definition is proclaimed by the instructor as a well-established fact and is supported by clearly aligned and unproblematic examples that should be resistant to questioning or contention. On the other hand, in concept formation lesson, students dialogically engage with examples under the guidance of an instructor and more openly negotiate the meaning of a concept and whether each given example meets the critical attributes of a conceptual definition. The alignment between a concept and the examples is deliberated and emerges dialogically rather than simply assumed as given and unproblematic a priori (Fig. 2).

Data Collection

All course meetings throughout the semester were video-recorded using the Echo360 Active Learning Platform (Echo360 2015), a computer system of lecture capture that can be used to digitally record audio and video of an instructor on a podium, as well as materials displayed through the projector (e.g., PowerPoint slides). Through the use a wide-angle ceiling camera located in the back of the room and a high-sensitivity lapel microphone worn by the instructor, this minimally intrusive system enables capture of instructor's actions as well as student comments, thus being particularly well suited for the naturalistic study of social conduct without any form of researcher bias or interference.

At the end of the course, students were asked to anonymously fill out a questionnaire that prompted them to articulate their experiences learning from examples during the semester, and administered as an individual, paper-based survey (Robson 2002) on the last day of class. This format helped ensure a high response rate by providing respondents with a safe and straightforward way of voicing their opinions and sharing their experiences. This was particularly important since the relatively large class size made interviewing all students unfeasible. Instead, the larger group of students were simply provided with the following open-ended prompts:

1. THIS IS NOT A TEST, we are only interested in hearing about your thoughts on this process and its effectiveness as a tool for teaching and learning Animal Behavior. Please write as much or as little as you wish.
2. What was an example that you remember particularly well from this class? Please describe the example (you can also a drawing or illustration). Also, explain why this particular example stood out in memory.

Students' written and oral responses provided us with an evidential basis to assess the extent to which their acquired conceptual knowledge became biased toward taxonomic groups that dominated the instructors' examples during the course.

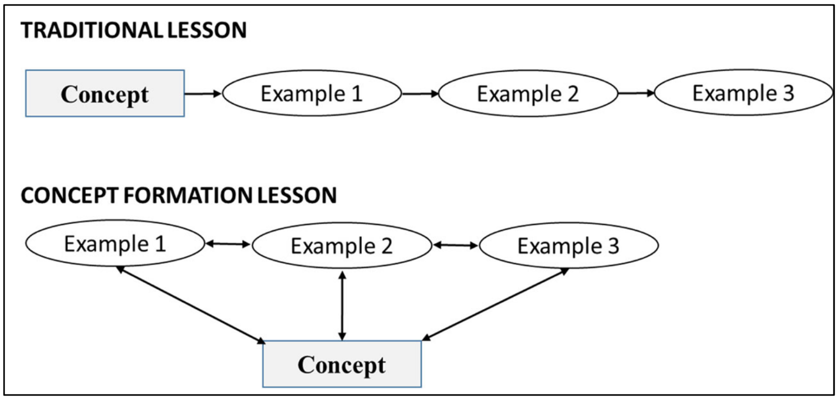

Fig. 2 Pedagogical format of traditional and concept formation lessons

Subsequent to their completion of the surveys, students were invited to participate in focus-group interview sessions. Typically deployed in educational research to help interpret the results of a survey (Bernard 2002), the focus-group method has been shown to be effective in stimulating thoughtful talk among participants and in revealing a range of views or perspectives on a particular topic or experience (Bogdan and Biklen 2003). These focus-group interviews afforded us opportunities to probe further into students' experiences by posing clarification questions and asking students to elaborate on their written responses.

Data Analysis

Consistent with naturalistic research traditions (Lincoln and Guba 1985), our analytical focus emerged through extended and careful examination of the large qualitative data set that ensued. Rather than being focused on taxonomic distribution a priori, this focal point emerged from our initial inspection of the collected data which suggested that instruction was to a certain degree being dominated by mammal and bird examples. Further, the course was examined as it had been normally taught in previous semesters, without any form of researcher interference or intervention. For the most part, the same examples had been used in previous iterations of the class.

Once taxonomic distribution was selected as a focal point, we created an exhaustive and chronological list of all examples given throughout the course based on a systematic review of our transcribed video-recordings. The examples used by the instructor to present the material were then categorized according to the taxonomic group of the animal whose behavior was being illustrated. In other words, our analytical examination of the instructor's exemplification practices focused on the relative frequencies whereby the instructor selected a mammal, bird, fish, reptile, amphibian, arthropod, or gastropod as the performing actor responsible for each exemplified action. These taxonomic frequencies served as the main empirical basis for our characterization of dominant images in animal behavior exemplification (Question 1).

Quantification of the instructor's taxonomic choices was supplemented by a qualitative analysis of the instructor's exemplification practices. In addition to determining how frequently the instructor mentioned members of particular taxonomic groups, we also sought to characterize the instructor's behavioral references (how he referred to animal action). As part of this analysis, we looked for qualitative evidence of anthropomorphism and personification. More specifically, we examined how the instructor's word choices, grammatical constructions, etc., gave rise to anthropomorphic (human-like) references and non-anthropomorphic references of animal behavior. As emphasized by Carlson (2006a, b), *generic reference* (how we refer to things/beings) is central to the linguistic construction of generic conceptualizations (how we make sense of things/beings).

The above analysis focused on more nuanced aspects of the instructor's ventriloquism (Bakhtin 1986)—ability to speak in the voice of anthropomorphized animals to illustrate the topic under discussion. Far from simple, such a practice requires pedagogical skill in *heteroglossia* (Bakhtin 1981) or plurality of voices. The instructor needs to be able to momently and strategically speak "through" a voice that is not his own without confusing students or making the example unclear. Doing so involves shifting back and forth among voices at the right time as well as clearly separating one's voice from that of another being (the speaking animal or animals). The latter can be accomplished in various ways, including direct speech (explicitly marked by air quote gestures or prefaces such as "The butterfly would be saying…"). Alternatively, the instructor can simply resort to indirect speech, shifting into the voice of an animal without quoting or explicit signaling. Author 3 favored the latter approach. Its complexity was particularly evident during this delivery of an example of territorial behaviors among butterflies of various ages:

> Author 3: Despite the fact that they [butterflies] are not better, they are older, they are damaged, they may be weakened, they may have lesser fat reserves and the likes but, *gosh, darn it*, they are just going

> to give it their all because *what have I* [the older butterfly] *got to lose?* So, putting it in terms of costs and benefits really helps to explain the economics of these kinds of decisions.

When giving the above example, Author 3 shifts back and forth between his own instructor voice and the voice of an older butterfly (*gosh, darn it… what have I got to lose?*), conveying the older butterfly's perspective while simultaneously commenting on its territorial behavior in the voice of a behavioral biologist. His voice shifts are rather implicit, being marked solely by strategic prosodic shifts—subtle changes in intonation. While space limitations prevent us from providing more details, a more comprehensive account of our qualitative findings can be found elsewhere (Oliveira and Brown 2016).

To assess the degree to which conceptual knowledge acquired by students may have become biased toward dominant taxonomic groups (Question 2), we turned to our survey and interview data. This analysis focused specifically on the taxonomic distribution of the examples of animal behavior identified by students as being memorable in their survey responses at the end of the course. Examples of animal behavior mentioned by students were also listed and categorized according to the taxonomic group (Table 1).

The use of multiple rich data sources allowed for triangulation and helped enhance the validity our findings (Patton 2002; Creswell 2007). By comparing video, interview, and survey data, we sought to create analytical consistency and provide a trustworthy account of the phenomena at hand. We combined systematic examination of written records from student testimonials with detailed sequential analysis and playback of video-recorded interaction in the classroom of instruction, giving rise to this emergent account.

Table 1 Sample comments from students' survey responses

Taxon	Student commentary
Mammals	[I remember well] Stotting in *gazelles* because I had never seen it before. However after understanding that it is not a random behaviour but rather a behaviour that demonstrates fitness I found it rather interesting.
	[I remember well] the *mole rat*. I found it super interesting how the queen ran the whole show and had all these little workers running around (not being able to see) a dark underground complex network of tunnels. Great example of eusociality!
	[I remember well] the *Belding's ground squirrel* warning tactic in which one may sacrifice itself for the group. It's interesting to see how an animal would sacrifice itself for another's survival by heroically and selflessly giving its life for another's.
Birds	Definitely brood parasitism. The *cuckoo* is such a huge bird, and it goes unnoticed in this regard among the tiny *warblers*. I found it so interesting that parental instincts may so strong that the parents would care for a *bird* that clearly isn't theirs.
	[I remember well] the *Bower birds'* display of its bower. The mating tactic of developing such an incredibly decorated bower with only its beak was really impressive.
	The example of the *Northwestern crows* when they developed an optimal strategy in which to open whelks in order to feed, while expending the least amount of energy possible to get the most food possible, by finding a height at which to drop them and not having to go any higher than that.
Arthropods	The example of behaviour of which the female *Praying mantis* would eat a male after copulation in order to have an "easy," close, accessible food supply for its offspring.
	The example from this class was the *beetle* where the female enforced monogamy by pushing the male when he began to emit pheromones to attract other mates.
	I loved learning about the waggle dance in *bees!* I found it to be an amazing adaptation to eusociality and resource gathering/sharing. *Bees* are incredible animals!
Reptiles	[I remember well] the behaviour of push up done by the *lizard* as an honest signal of its physically fit nature, leading to predators abandoning the chase. It has stuck with me because it would seem like a death wish by the *lizard* but it is an honest signal.
	The *Marine iguana* and how the subordinates prematurely ejaculate in order to successfully mate. It stuck with me because that is not a desirable train in humans whatsoever, but it works out alright for *lizards* apparently.
	The *lizards* that have evolved the conditional strategy to have a speedier ejaculate. Why: the instructor's reenactment of a more dominant *lizard* scurrying over and saying "Oh no you didn't!" If more the more submissive *lizard* takes a long time to ejaculate.

Results

Exemplification in the classroom instruction was dominated by anthropomorphic images mammals and birds. Furthermore, these dominant images were found to have strongly biased the conceptual knowledge acquired by the students.

Instructor's Taxonomic Choices

Our video-based examination revealed that a total of 172 distinct examples of animal behavior were given throughout the duration of the course, with an average of approximately 13 examples per week. As shown in Table 2, the majority of all examples given during the semester involved birds and mammals (60%). Among the remaining taxa, arthropods were particularly frequent (28%), with reptiles, amphibians, fish, and gastropods comprising a very small minority (12% combined).

Consistent with the above trends, students commented explicitly on the dominance bird examples throughout the course during the focus-group interviews:

> Interviewer: What is an example that, the first one that you think of, a behaviour described in class, what's one you remember really well?
> Student 1: The Bower bird.
> Interviewer: And, do you know why you remember it so well, or more than others?
> Student: I think he [instructor] used that example so many times that, everything just kept coming back to it.
> Interviewer: So, maybe it's one of his favorites.
> Student 2: Something that I didn't really like about some of the examples is that, like, all the examples were all about birds, and it was kind of boring, like, I am not saying like, well maybe it's because those characteristics are presented by birds, but it was really, really boring, but sometimes talking about all these different sets of birds, I don't know, it's just something I really didn't like.
> Interviewer: So, having a larger variety of species would have been better, because it would interest more people?
> Student 2: Right.

As can be seen, some students felt that an excessive number of examples involving birds was given during the course, and would have desired that the instructor taxonomically diversify his exemplification practices. Such a strong dominance of avian behavior is seen as a potential barrier to the engagement of some students whose personal preferences and research interests may lie with different categories of animals.

Instructor's Behavior References

The instructor's exemplification practices were also dominated by anthropomorphic types of behavior references. As can be seen in Table 3, when giving examples, the instructor often introduced miniature

Table 2 Frequencies of taxonomic groups in the instructor's examples

	Taxonomic group							Total
	Mammals	Birds	Reptiles	Amphibians	Fish	Arthropods	Gastropods	
Number of examples given by instructor	48	54	10	2	8	49	1	172

Table 3 Examples of animal behavior orally given by instructor for each taxonomic category

Taxon	Example
Mammals	Instructor: We're talking about **Big Horn sheep** here, living in a precarious environment up on the ledges of cliffs. Males will want to come in and get access to this female, and the male that has mated with her doesn't want that! So look what he does [watching video]. Actually, he's got two females that he's protecting. And he's obviously looking to control the paternity of these females and other males are looking to come along and want get some of that. And so the primary male just gets in the way and says: *Oh no you di-in't!* [watching video] These guys are persistent.
Birds	Instructor: Here what we have is **Long-tailed manikins**. These types of **birds** here which have an interesting display for courtship which involves two males to court a particular female. The two males will do this dance where they will sort of be side-to-side on the branch with the female at one end… [performing bird dance] that is basically the courtship dance to seduce the female involving two males. Now it is important to note that only one of these males will get that reproductive event that the female will say *okay, I like this duet that you are doing here, I am willing*. And so, at that point alpha male says *okay, thanks beta male, you have done your job, now I get to reproduce, alright?*
Arthropods	Instructor: So there may be parental favoritism going on. We have seen the **Burying beetles** already, which are the **beetles** that laid eggs in rotting carcasses in the ground, this is one species that lays eggs in lumps of dung. And so, what they do is they fashion balls from dung that is found in the environment and lay eggs into them. And once the first brood has emerged they lay a second brood in the same ball of dung, but they will only feed the first brood by mouth-to-mouth regurgitation, a process known as trophallaxis, which basically means sort of food provisioning/sharing. And this trophallaxis is a means by which they can add extra care to the offspring. But they only do so for the first brood and not the second brood.
Fish	Instructor: There can be some situations in which males contribute great amounts of parental care and this happens often in **fish**. And so, what we see as examples here are illustrations of when adult male **St. Peter's Fish** provide parental care [referring to figure on screen]. Because, what they contribute to the survivorship of the offspring is important to their own reproductive fitness. So, what we find in many cases with **fish** is this mouth brooding where the males, in general, will take the clutch of eggs in their mouth and this will help to protect them against predation, in that if they were just sort of lying around in the environment that they would be subjected to being eaten by other **fish**.
Reptiles	Instructor: The example that we're showing to illustrate this concept of having alternatives to playing the usual game [courtship] is with these **Marine Iguanas** of the Galapagos Islands, where the big males dominate all of the reproductive opportunities because subordinates can't engage in the regular process of mounting females and having sex and ejaculating before a big male comes along and says: *Oh no you di-in't!* and removes him. So those little ones never get those chances if they were to play the game according to those sort of traditional dominance-subordinate/submissive type of interactions.
Amphibians	Instructor: We see this with certain kinds of **toads** where there's a good male over here on the left calling for females doing his [croaks to imitate toad] trying to attract females. And this guy over here is like *well, I'm not going to be able to get much action by croaking, 'cause I'm not that attractive or dominant or capable, but if I hang out next to Mr. Popular-in-high-school over here*, when the female comes along and dumps out her eggs, well, he'll dump some sperm nearby. And even though he's not the closest to the eggs, he'll probably be able to produce some offspring as a 'satellite male'.
Gastropods	Instructor: What we're looking at here is a **Sea slug**. So, it's basically **a marine mollusk** whose main predator are starfish. And when the **Sea slug**, who's wandering about, or swimming about, in the aquatic column comes into proximity of its main predator it undertakes its evasive action which is sort of a flipping of the body. Contract upwards, contract downwards, contract upwards, contract downwards; so it's kind of making a "u" like this, and then it makes and "n," then a "u," and an "n" [shaping out the letters with arms]. And this is enough for it to flop away as fast as it can. Presumably it's fast enough, recognizing as well that starfish are not fast-moving animals, so this is an appropriate and a successful evasive mechanism, and seemingly complex, given the simple neuronal mechanism behind it.

dialogs, giving human-like voice to the animals involved in the behavior (*okay, thanks beta male, you have done your job, now I get to reproduce, alright?*). Taking the form of oral commentary, these voicings gave an imaginary and humorous account of how animals would react to their biological situation if they had the capacity to speak or the ability to produce fully realized sentient and self-reflective thoughts. Instances of anthropomorphism were usually quite different tonally and verbally from the surrounding explanations, with the instructor usually adopting a more casual and mirthful language (*Oh no you di-in't!*).

Students' Memorable Examples

Examples with mammals and birds were also mentioned more often by students than other types of animal examples. Of the 53 examples identified by students in their surveys, a total of 40 (75%) involved birds and mammals (Table 4). In contrast, arthropod examples were mentioned considerably less frequently (15%), and amphibians and gastropod examples were not mentioned at all by students.

Mammalian and avian images also dominated students' drawings. In addition to verbally identifying the examples that stood out in their memory, several students also visually depicted them in the form of drawings. These visual illustrations were invariably focused on birds and mammals (Fig. 3).

Discussion

At the onset of this paper, we raised the possibility of learning impacts from dominant exemplification in undergraduate biology teaching. Based on existing research at the K-12 school level, we set out to determine whether similar patterns also occurred in an undergraduate biology course (Question 1) and the extent to which it impacted students (Question 2). We now consider how the above results provide answers to our original research questions and discuss the significance of our findings in light of the existing literature.

Dominant Exemplification and Student Bias

As reported above, animal behavior instruction was indeed dominated by examples about mammals and birds (gazelles, squirrels, cranes, cuckoos, etc.). These two taxonomic groups figured prominently as the most frequent images in the examined undergraduate biology course, comprising over 60% of all examples used by the instructor to illustrate the scientific study animal behavior. Further, we found a tendency among students to conceive of nonhuman conduct in terms of mammalian and avian action. Of the 53 examples that stood out in students' memory after the class, a total of 40 (75%) involved birds and mammals, hence indicating that the conceptual knowledge acquired by the students in fact had a certain degree of bias toward this two taxonomic groups.

The above finding is consistent with recent psychological studies showing that people learn to associate behaviors with categories/groups that figure prominently in their social environments (i.e., salient categories: Meiser and Hewstone 2004; Le Pelley et al. 2010). A central factor in associative learning is frequency of recurrence. In the examined biology course, recurrent exposure to examples involving mammals and birds (salient biological categories) seemed to foster a similar cognitive process wherein the behavioral information mentally encoded and stored in students' long-term memory was biased by association with

Table 4 Frequencies of taxonomic groups in students' survey responses

	Taxonomic group							Total
	Mammals	Birds	Reptiles	Amphibians	Fish	Arthropods	Gastropods	
Number of examples identified by students	23	17	4	0	1	8	0	53

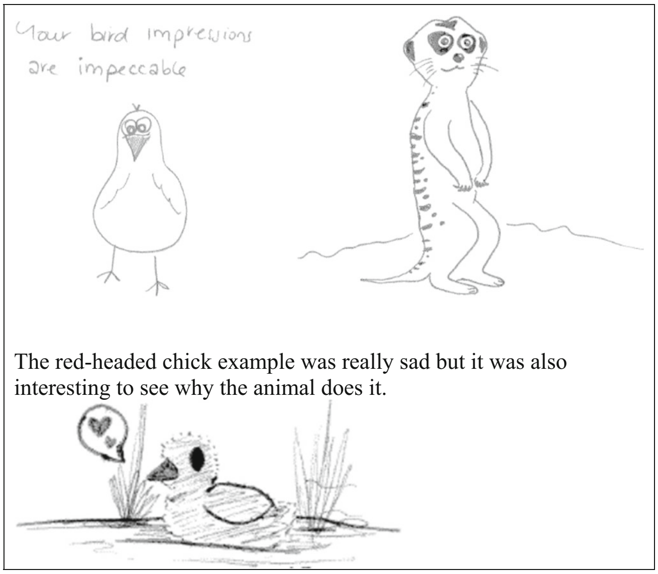

Fig. 3 Students' drawings of memorable examples

these two taxonomic groups. The salience of these two categories in students' memory may have led to a propensity to conceive of nonhuman conduct in terms of mammalian and avian action.

Students' propensity to automatically refer to biological situations involving birds and mammals also suggests that students developed a *personal example space* (Watson and Mason 2005) with a relatively narrow scope. The conceptual knowledge that students had access to as a result of taking the course appeared somewhat circumscribed to birds and mammals. Members of other taxonomic groups (arthropods, fish, reptiles, and amphibians) infrequently came to students' mind and appeared to remain for the most part excluded from students' thinking (i.e., were beyond what students seemed to recognize as the range of biological possibilities with regard to animal behavior).

Dominant exemplification was also characterized by a high degree of anthropomorphism. Not only were dominant examples about mammals and birds, but they also included casual and humorous commentary wherein these animals were given human-like voices, thoughts, and agency over their actions. Rather than leading to confusion and misunderstanding as many have argued (Kallery and Psillos 2004; Prokop et al. 2007), the instructor's anthropomorphic examples seemed to have effectively engaged the students and may have added clarity to abstract behavioral concepts under consideration. Such a finding suggests that, at least at the undergraduate level, anthropomorphism can indeed be beneficial to students and that university instructors should remain open to the possibility of capitalizing on its potential to serve as a pedagogical tool (Legare et al. 2013). As emphasized by post-humanist philosophers such as Wolf (2008), it is only by imaginatively extending the faculty of speech to nonhuman animals and hearing them "speak our language" that we will possibly be able to reconcile the ontological divide that separates human from nonhuman beings in scientific thought and re-conceptualize animals as "fellow creatures" with whom we share our planet as well as our mortality (finitude).

Impacts on Student Engagement and Creativity

A somewhat unexpected but equally important result was the adverse impact that dominant exemplification seemed to have on student engagement. As described above, one student considered the number of examples involving birds to be excessive and a source of personal boredom. Put differently, dominance of avian behavior became a barrier to learner's engagement. This finding is particularly important given that previous studies have shown that university science instructors frequently struggle with the problem of vigilance decrement (Young et al. 2011)—rapid decay in student concentration and attention over the course of a lecture. Because the traditional reading-style lecture remains the predominant method of teaching at the university level (Sutherland and Badger 2004; Jones 2007), student disengagement constitutes a major concern to educators (Mann and Robinson 2009). As our results show, changing to a more dialogical lecture format like a concept formation lesson may not effectively act to combat student boredom and vigilance decrement if the instruction is too strongly dominated by particular example types. In the specific context of an animal behavior biology course, keeping students engaged may therefore require having a taxonomically diverse pool of examples, beyond that of birds and mammals alone.

An added benefit of diversified exemplification practices is increased student creativity toward concept formation, understanding, and communication. Despite their potential to promote student learning of the underlying cognitive structure of conceptual problems, worked examples can also have a constraining impact on student creativity. Previous psychological studies have provided evidence that exemplification can have a “conformity effect” on receivers (Smith et al. 1993; Galinsky et al. 2008). These studies report that participants who are shown examples while engaged in creative generation tasks tend to be less creative (i.e., they generate ideas whose features are similar to the examples received). This may decrease the effectiveness of the teaching and learning strategies by limiting student abilities to transfer and apply their knowledge to new situations. Likewise, the taxonomic similarity of instructor and student examples of animal behavior can be taken as an indication of reduced student creativity, a potential impact that will need to be examined further by future research.

Implications and Conclusions

> Biased are we, for most of us are brainwashed in childhood against anything devoid of hair or feathers… Even a mature and thoughtful man, imbued with reverence for living things, has not quite the same feeling for a beetle that he has for a squirrel. (Evans 1968)

As argued above by the famous entomologist and wasp expert Harold Ensign Evans, human attitudes toward animals are highly biased, showing a clear affinity for mammals and birds. Their biological similarity to humans creates an increased propensity for “social relatedness” (Myers and Saunders 2002), that is, people sympathize more with mammals and birds as “social others,” with whom they can relate emotionally, morally, and empathetically. In sharp contrast, most people react to insects and arachnids with some level of fear and/or disgust (Bennett-Levy and Marteau 1984; Lockwood 2013; Looy et al. 2014). This aversion has important implications to education as well as conservation efforts since people are more likely to protect charismatic species of birds and mammals (Kellert 1993) such as polar bears, for example. However, insects and other disgust- and fear-evoking arthropods are key ecosystem members and are crucial to the integrity of many food webs and ecosystem functioning (Losey and Vaughan 2006). Recognition and awareness of such an important ecological role requires a pedagogical exposure to insects. As argued by Pitt and Shockley (2014), ignorance breeds fear, but access to entomology education can help to combat this problem and reshape how the public perceives insects and arachnids. This is precisely why giving more examples involving arthropods, fish, reptiles, and amphibians may play an important role in biology education. By extending their exemplification beyond mammals and birds, biology instructors may be able to influence students’ attitudes toward animals in general and potentially counter such prevalent biases.

In conclusion, the use of examples in scientific teaching has a long history, and for good reason. In biology, animal examples play an important role in shaping students’ knowledge and recognition of biodiversity. Extending biological exemplification practices beyond mammals and birds is essential if students are to be able to fully conceptualize the existence of nonhuman organisms and develop a deep and unbiased appreciation of life. As Ildefonso (2011) posits, students should learn to "look at life as an open-ended question, full possibilities" (p.55). This is precisely what well-crafted instructor exemplification practices should try to accomplish.

References

Alcock, J. (2013). *Animal behavior* (10th ed.). Sunderland, MA: Sinauer Press.

Bakhtin, M.M. (1981). Discourse in the novel. In M. Holquist (Ed), *The dialogic imagination*. Austin, TX: University of Texas Press.

Bakhtin, M. (1986). The problem of the text in linguistics, philology and the human sciences. In C. Emerson & M. Holquist (Eds.), *Speech genres and other late essays* (pp. 103–131). Austin: University of Texas Press.

Ballouard, J.M., Brischoux, F., & Bonnet, X. (2011). Children prioritize virtual exotic biodiversity over local biodiversity. *PloS one*, 6(8), e23152.

Bednekoff, P.A. (2005). Animal behaviour in introductory textbooks: Consensus on topics, confusion over terms. *Bioscience*, 55, 444–448.

Bennett-Levy, J. and Marteau, T. (1984). Fear of Animals: What is prepared? *British Journal of Psychology*. 75: 37–42.

Bernard, H.R. (2002). *Research methods in anthropology: Qualitative and quantitative approaches* (5th ed). Walnut Creek, CA: AltaMira Press.

Bills, L., Mason, J., Watson, A., & Zaslavsky, O. (2006). RF02: Exemplification: The use of examples in teaching and learning mathematics. In J. Novotná, H. Moraová, M. Krátká, & N. Stehlíková (Eds.), *Proceedings of the 30th annual conference of the International Group for the Psychology of Mathematics Education, Vol. 1* (pp. 125–154). Prague: PME.

Bogdan, R.C. & Biklen, S.K. (2003). *Qualitative research for education: An introduction to theory and methods* (4th ed). Boston: Allyn & Bacon.

Busselle R.W., & Shrum, L.J. (2003). Media exposure and exemplar accessibility. *Media Psychology*, 5, 255–282.

Carlson, G. (2006a). Reference. In L. Horn, and G. Ward (Eds.), *The handbook of pragmatics* (pp. 74–96). Oxford, UK: Wiley-Blackwell.

Carlson G. (2006b). Generic reference. In K. Brown (Ed.), The encyclopedia of language and linguistics (2nd ed) (pp. 14). Elsevier.

Celis-Diez, J.L., Díaz-Forestier, J., Márquez-García, M., Lazzarino, S., Rozzi, R., Armesto, J.J. (2016). Biodiversity knowledge loss in children's books and textbooks. *Frontiers in ecology and the environment*. 14(8), 408–410.

Coley, J.D., Solomon, G.E.A., & Shafton, P. (2002). The development of folkbiology: A cognitive science perspective on children's understanding of the biological world. In P.H. Kahn & S.R. Kellert (Eds), *Children and nature: Psychological, sociocultural, and evolutionary investigations* (pp. 65–92). Cambridge, MA: The MIT Press.

Cook, K. (2009).Asuggested project-based evolution unit for high school: Teaching content through application. *The American Biology Teacher*, 71, 95–98.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks, CA: Sage Publications.

Creswell, J.W., (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd). Thousand Oaks, CA: Sage.

das Neves, J.P.C. and Monteiro, RCR (2014). How full is your luggage? Background knowledge of zoo visitors regarding sharks. *Environmental Education Research*, 20, 3, 291–312.

Dove, J. (2011). Rainforest depiction in children's resources. *Journal of Biological Education*, 45(4), 208–212.

Echo360 (2015). *Echo 360 active learning*. Retrieved on May 12th 2015 from http://echo360.com/

Evans, H. E. (1968). *Life on a little-known planet*. New York: Dutton.

Galinsky, A.D., Magee, J.C., Gruenfeld, D.H., Whitson, J.A., & Liljenquist, K.A. (2008). Social power reduces the strength of the situation: Implications for creativity, conformity, and dissonance. *Journal of Personality and Social Psychology*, 95, 1450–1466.

Gopnik, A., & Meltzoff, A. N. (1998). *Words, thoughts, and theories*. Cambridge, MA: MIT Press.

Halmos, P.R. (1983). *Selecta: Expository writing*. New York: Springer.

Huxham, M., Welsh, A., Berry, A., & Templeton, S. (2006). Factors influencing primary school children's knowledge of wildlife. *Journal of Biological Education*, 41 (1), 9–12.

Ildefonso, G.M. (2011) Not a laughing matter: The value of leisure in education. *Curriculum Inquiry*, 41, 48-56.

Jones, S. (2007) Reflections on the lecture: Outmoded medium or instrument of inspiration? *Journal of Further and Higher Education*, 31(4), 397–406.

Kahn, P.H. (1999). *The human relation with nature: Development and culture* (pp. 25–43). Cambridge, MA: MIT Press.

Kallery, M., & Psillos, M. (2004). Anthropomorphism and animism in early years science: Why teachers use them, how they conceptualize them and what are their views on their use. *Research in Science Education*, 34, 291–311.

Kellert, S.R. (1993). Values and perceptions of invertebrates. *Conservation Biology*, 7, 845–855.

Le Pelley, G.C., Reimers, S.J., Calvini, G., Spears, R., Beesley, T., & Murphy, R.A. (2010). Stereotype formation: Biased by association. *Journal of Experimental Psychology*,139, (1), 138–161.

Legare, C. H., Lane, J. D., Evans, E. M. (2013). Anthropomorphizing science: How does it affect the development of evolutionary concepts? *Merrill-Palmer Quarterly* 59, 168–197.

Lincoln, Y.S., & Guba, E.G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage Publications.

Lindemann-Matthies, P. (2005). "Loveable" mammals and "lifeless" plants: How children's interest in common local organisms can be enhanced through observation of nature. *International Journal of Science Education*, 27(6), 655–677.

Lockwood, J.A. (2013). The infested mind: Why humans fear, loathe, and love insects. New York, NY: *Oxford University Press*.

Looy, H., Dunkel, F. V., & Wood, J. R. (2014). How then shall we eat? Insect-eating attitudes and sustainable foodways. *Agriculture and Human Values*, *31*, 131–141.

Losey, J.E., & Vaughan, M. (2006). The economic value of ecological services provided by insects. *Bioscience*, 56(4), 311–323.

Magntorn, O., & Helldén, G. (2007). Reading new environments: Students' ability to generalise their understanding between different ecosystems. *International Journal of Science Education*, 29(1), 67–100.

Mann, S., & Robinson, A. (2009). Boredom in the lecture theatre: An investigation into the contributors, moderators and outcomes of boredom amongst university students. *British Educational Research Journal*, 35, 243–258.

Meiser, T., & Hewstone, M. (2004). Cognitive processes in stereotype formation: The role of correct contingency learning for biased group judgement. *Journal of Personality and Social Psychology*, 87, 599–614.

Myers, O.E., & Saunders, C.D. (2002). Animals as links toward developing caring relationships with the natural world. In P.H. Khan & S.R. Kellert (Eds), *Children and nature: Psychological, sociocultural, and evolutionary investigations* (pp. 153–175). Cambridge, MA: MIT Press.

National Research Council (2012). *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering*. Washington, DC: The National Academies Press. doi:https://doi.org/10.17226/13362.

Oliveira, A.W., & Brown, A.O. (2016). Exemplification in science instruction: Teaching and learning through examples. *Journal of Research in Science Teaching*, 53, 737–767.

Orlander, A.A. (2016). 'So, what do men and women want? Is it any different from what animals want?' Sex education in an upper secondary school. *Research in Science Education*, 46, 811–829.

Ormrod, J.E. (2012) *Concept learning. In N.M. Seel (Ed), Encyclopedia of the sciences of learning* (pp. 728–729). Switzerland: Springer.

Parker, W.C. (1988). Thinking to learn concepts. *Social Studies*, 79, 70–73.

Parker, W.C. (2011). *Social studies in elementary education*. Boston, MA: Allyn and Bacon.

Patton, M.Q. (2002). Qualitative research and evaluation methods. Thousand Oaks, CA: Sage.

Pitt, D.B., & Shockley, M. (2014). Don't fear the creeper: Do entomology outreach events influence how the public perceives and values insects and arachnids? *American Entomologist*, 60 (2), 97–100.

Prokop, P., Kubiatko, M., & Fančovičová, J. (2007). Why do cocks crow? Children's concepts about birds. *Research in Science Education*, 37 (4), 393–405.

Randler, C. (2008). Teaching species identification: A prerequisite for learning biodiversity and understanding ecology. *Eurasia Journal of Mathematics, Science & Technology Education*, 4(3), 223–231.

Robson, C. (2002). *Real world research* (2nd ed). United Kingdom: Blackwell Publishing.

Rumbaugh, D.M., King, J.E., Beran, M.J., Washburn, D.A., & Gould, K. (2012). A salience theory of learning. In N.M. Seel (Ed.), *Encyclopedia of the sciences of learning* (pp. 1–4). Germany: Springer.

Smith, S.M., Ward, T.B., & Schumacher, J.S. (1993). Constraining effects of examples in a creative generation task. *Memory and Cognition*, 21, 837–845.

Snyder, V.L., & Broadway, F.S. (2004). Queering high school biology textbooks. *Journal of Research in Science Teaching*, 41, 617–636.

Sutherland, P., & Badger, R. (2004). Lecturer's perceptions of lectures*. Journal of Further and Higher Education*, 28(3), 277–289.

Tomasello, M. (2000). *The cultural origins of human cognition*. Cambridge, MA: Harvard University Press.

Tsamir, P., Tirosh, D., & Levenson, E. (2008). Intuitive nonexamples: The case of triangles. *Educational Studies in Mathematics*, 69(2), 81–95.

Turiel, E. (1998). Moral development. In W. Damon (Ed.) *Handbook of child psychology (Vol. 3)* (5th ed.) (pp. 863–932). New York: Wiley.

Waldenfels, B. (2015). For example. In M. Lowrie, & S. Ludemann (Eds.), *Exemplarity and singularity: Thinking through particulars in philosophy, literature, and law* (pp. 36–43). New York, NY: Routledge.

Watson, A. & Mason, J. (2005). *Mathematics as a constructive activity: Learners generating examples*. New York, NY: Routledge.

Wolf, C. (2008). Flesch and finitude: Thinking animals in (post)humanist philosophy. *SubStance*, 37(3), 8–36.

Yen, C.F., Yao, T.W., & Mintzes, J.J. (2007). Taiwanese students' alternative conceptions of animal biodiversity. *International Journal of Science Education*, 29(4), 535–553.

Young, M., Robinson, S., & Alberts, P. (2011). Students pay attention!: Combating the vigilance decrement to improve learning during lectures. *Active Learning in Higher Education*, 10, 41–55.

Zillman, D. (1999). Exemplification theory: Judging the whole by some of its parts. *Media Psychology*, 1, 69–94.

Zillman, D. & Brosius, H.D. (2000). *Exemplification in communication: The influence of case reports on the perception of issues*. Mahwah, NJ: Lawrence Earlbaum.