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Environmental agency in read-alouds

Alandeom W. Oliveira • Patterson Rogers • Cassie F. Quigley • Denis Samburskiy • Kimberly Barss • Seema Rivera

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Abstract Despite growing interest in helping students become agents of environmental change who can, through informed decision-making and action-taking, transform environmentally detrimental forms of human activity, science educators have reduced agency to rationality by overlooking sociocultural influences such as norms and values. We tackle this issue by examining how elementary teachers and students negotiate and attribute responsibility, credit, or blame for environmental events during three environmental read-alouds. Our verbal analysis and visual representation of meta-agentive discourse revealed varied patterns of agential attribution. First, humans were simultaneously attributed negative agentive roles (agents of endangerment and imbalance) and positive agentive roles (agents of prevention, mitigation, and balance). Second, while wolves at Yellowstone were constructed as intentional (human-like) agents when they crossed over into the human world to kill livestock in nearby farms, polar bears in the Arctic were denied any form of agential responsibility when they approached people’s homes. Third, anthropogenic causation of global warming was constructed as distal and indirect chains of cause and effect (i.e., sophisticated sequences of ripple effects), whereas its mitigation and prevention assumed the form of simple and unidirectional causative links (direct and proximal causality). Fourth, the notion of balance of nature was repeatedly used as a justification for environmental conservation but its cause and dynamic nature remained unclear. And, fifth, while one teacher promoted environmental agency by encouraging students to experience positive emotions such as love of nature, freedom, and oneness with nature, the other teachers encouraged students to experience negative emotions such as self-blame and guilt. This study’s main significance is that it highlights the need for environmental educators who set out to promote environmental agency to expand the focus of their instructional efforts beyond rational argumentation and reasoning. It also underscores the importance of increasing school teachers’ awareness of implicit discursive messages in particular patterns of environmental agency attribution when discussing environmental issues with students and implementing pedagogical strategies centered on oral deliberation such as read-alouds.

Keywords Agency • Read-aloud • Environment • Elementary school • Discourse
Экологическая агентивность в чтении вслух

Несмотря на возрастающий интерес к тому, чтобы учащиеся принимали активную позицию в улучшении окружающей среды и, посредством осознанно принятых решений и действий, могли бы изменить губительные формы человеческого влияния на природу, преподаватели естественно-научных дисциплин сели понятие «активная позиция» к рационализму, поскольку они не приняли в счёт влияние социокультурных норм и ценностей. Чтобы прояснить этот недочёт, мы исследовали то, как учителя и учащиеся начальных классов обсуждают понятия ответственности, заслуги или вины за происходящее с окружающей средой в чтении трёх книг о природе вслух. Наш лингвистический анализ и визуальное представление мега-агентивного дискурса выявили различные модели принятия «активной позиции». Во-первых, людям были одновременно приписаны негативные (агенты поддержания опасности и дисбаланса) и позитивные (агенты предохранения, смягчения отрицательных последствий и баланса) агентивные позиции. Во-вторых, несмотря на то, что волки из Йельсустона рассматривались как недопустимые (схожие с людьми) агенты, когда они вторились в мир людей и убили домашних скот в близлежащих фермах, белые медведи в Арктике были лишены какой-либо агентивной ответственности за то, что приближались к домам людей. В-третьих, антропогенная причинность глобального потепления рассматривалась как периферическая и каковая ценой причинно-следственных связей (т.е., похожа на серию «рибы на воде»), тогда как смягчение воздействия потепления имело форму простых и однонаправленных причинных вехочек (прямая и близкая причинность). В-четвертых, понятие «гармония в природе» многократно использовалось как определяющие обстоятельства для сохранения окружающей среды, хотя причина и линейный характер этого понятия остались неясными. Наконец, в-пятых, в то время как один учитель мотивировал «активную позицию» в защите окружающей среды (агентивность), вызывая у учащихся положительные эмоции, такие как любовь к природе, свободу и единство с природой, другие учителя вызывали к отрицательным эмоциям, таким как чувство собственной вины. Основная значимость данного исследования в том, что оно подчёркивает необходимость в учителях в области окружающей среды, которые мотивируют экологическую агентивность за пределами рациональной аргументации и мышления. Оно также демонстрирует важность в повышении уровня информированности школьных учителей в вопросах скрытых содержаний слов в определённых описаниях экологической агентивности при обсуждении проблем окружающей среды с учащимися и применении педагогических методов, фокусирующихся на устном размышлении, например, при чтении вслух.

Among science educators there is growing interest in how to imbue in students the capacity to become agents of environmental change who can, through informed decision-making and action-taking, reshape and transform environmentally detrimental and irresponsible forms of human relationship with nature. Such interest is particularly evident in Dana Zeidler and colleagues’ (2003) research on the use of socioscientific issues for teaching science, which has revealed varied patterns of student reasoning and argumentation in response to environmental dilemmas. Yet, this body of research fails to make systematic analytical employment of the theoretical construct of “agency,” focusing instead on unpacking logical relations (e.g., claim, data, warrant, qualifier, and rebuttal) in student argumentation. This incongruity is reflective of widespread conceptions of agency...
as strictly a sociocultural phenomenon. As such, the existing literature is inconsistent with recent work in the psychology of agency supporting a cognitive perspective on human agentivity. As Fausey, Long, Inamori, and Boroditsky (2010) write, “agency [is] a construct of paramount importance in human cognition” (p. 162).

Science educators’ focus on environmental rationality abstracted from sociocultural context also suggests a strong reliance on what Ahearn (2001a) identifies as a rational choice model wherein agency is equated to absolute free will, and activity (action and decision-making) conceived as being pursued by self-interested and rational individuals who are unaffected by societal influences (e.g., social norms, shared cultural values). By favoring a model of agency that situates environmental activity in the mental processes of human actors (i.e., as solely a matter of rationality), science educators have generally overlooked sociocultural aspects of human activity and treated humans as “super-rational” and “asocial” beings. In Burns’ (1994) words,

[A rational choice approach] emphasizes the volitional nature of human action and the capability of actors to make decisions and to act on the basis of rational calculations of benefit and cost. Individuals are assumed to be more or less fully informed about their action situations and to choose the best actions or means to achieve their ends… given the information (perfect or less than perfect) that the individual has about his or her “given environment” and about his “feasible set of options”… [As a result, agency] becomes in a certain sense a simple exercise in calculus (p. 198).

The present study seeks to tackle this limitation in the science education literature by examining how classroom discussion of environmental issues is socioculturally mediated, that is, linked to linguistically constructed roles and relationships with the environment. Instead of reducing it to rationality, we define environmental agency more broadly as the capacity to act upon environmental issues (i.e., the capability of actively resolving environmental problems) which can be expressed or demonstrated orally by elementary teachers and students through oral language use during read-alouds. By situating environmental agency in teacher–student verbal interactions, we seek to answer the following research question: How is environmental agency (the capacity to act upon environmental issues) expressed and demonstrated by elementary teachers and students during read-alouds?

Theoretical models of agency

Despite its pervasive usage across social sciences, “agency” remains a term whose theoretical meaning is often defined too narrowly, unclearly, and simplistically. Some have treated agency as synonymous to free will and resistance, a stance often criticized for its failure to take into account sociocultural forces and tendency to overlook the complex and ambiguous nature of human intentionality, activity, and belief systems (Ahearn 2012).

Several researchers emphasize the ambiguous and problematic nature of agency attribution. Wertsch et al. (1993) question whether the machine itself or its user should bear responsibility over the completion of tasks involving computer-mediated activity. Goodwin (1994) reports how, while using the same videotape as evidence during a court trial, the prosecution presents Rodney King as a helpless victim of a brutal beating by police officers (agents of uncontrolled brutality), whereas the defense describes King as a dangerous giant who, despite lying on the ground, was in control of the situation and continued
to act aggressively against the officers who merely reacted with escalated force to defend themselves (i.e., King was the agent of his own beating). Roth (2007) argues that human agency and passivity are inherent to all human action as people cannot act upon the world without being simultaneously affected by it; being an agent also inevitably entails being a recipient of the outside world’s influence. Ahearn (2001b) describes how agency is expressed differently across languages: in some the subject of intransitive verbs (e.g., Paul fell down) is treated as an agent (Paul is the agent of his own demise), whereas in others it is treated as an object (Paul is a passive recipient upon whom the event of falling befalls). Not only is linguistic attribution of agency highly ambiguous but it can also be manipulated as a means of pursuing one’s personal interests and agenda.

Oliveira (2012) points out how theoretical models used to understand human agency in the context of social systems or structures can be grouped into three main themes. In a mechanistic theme, human agency is treated in a deterministic manner as simply the result of an existing social organization that remains unaffected by human choice or free will. This precludes the possibility of cultural transformation or change by assuming that human agency is socially conditioned (Carspecken 1996). Structuralist themes on the other hand view human agency as emerging from the routine activity or practice of individuals in particular social structures in a mutually constituting relationship—human actions are not only shaped by social structures (i.e., cultural reproduction) but can also change existing socio-structural conditions (i.e., cultural transformation). Change is possible, despite the constraints of a self-reproducing structure, due to inherent structural tensions and contradictions leading to the “loose structuring” of humans whose actions are not completely free nor completely socially determined (Ortner 2001). Lastly, cultural themes embrace the notion that human agency requires volition—a mental state characterized by intentionality, motivation, rationality, and action monitoring. As a result of emphasizing rational choice, culturalist themes treat human agency as free will, a capacity exercised by completely autonomous individuals. Such a rational model has been criticized for overlooking cultural, institutional, and normative influences on human activity (Ahearn 2001a).

Linguist anthropologists such as Ahearn (2001b) have defined human agency as “the socioculturally mediated capacity to act” (p. 112). Such stance on human agency cohesively combines structuralist and cultural themes and has been used to examine how social transformation is actively pursued within a particular social structure through the volition (rational and reflective choice) and activity (e.g., discursive interactions) of social agents despite the existence of reproductive constraints (a culture that favors the existing social structure). Agency is viewed as linguistic and emergent in nature, being grammatically encoded and constituted through the ways that speakers and writers use language. As emphasized by Ahearn (2001a), “linguistic resources can be used to exercise, attribute, or deny agency” (p. 120). As evidence, Ahearn (2003) describes how the language used by writers of love letters in Nepal express individual agency over their romantic relationships (i.e., communicate love as product of their own agency rather than something that simply happened to them). Influenced by this research, we conceive of read-alouds as social events wherein elementary teachers and students can demonstrate environmental agency (i.e., express an ability to transform their personal relations with the natural environment) through the provision of agentive verbal representations (utterances) concerning nature protection issues.

In doing so, we seek to adopt a more sophisticated model of environmental agency—as a socioculturally mediated capacity to transformatively interact with environmental social structures—that can help us better understand the micro-processes of social reproduction and social transformation underlying teachers’ efforts at promoting student environmental
awareness. Our model highlights that environmental agency “extends beyond the skin” (Wertsch, Tulviste, and Hagstrom 1993), that is, it is not strictly located inside the mental processes of individuals. Rather, environmentally protective behavior emerges in students’ sociocultural interactions with existing environmental social structures (i.e., prevailing human–environment relations), being mediated by semiotic tools such as *meta-agentive discourse* which Ahearn (2012) defines as

> how people talk about agency – how they talk about their own actions and others’ actions, how they attribute responsibility for events, how they describe their own and others’ decision-making processes (p. 284).

Put differently, we consider environmental agency as emerging discursively from teachers’ and students’ ways of negotiating and attributing responsibility, credit, or blame for environmental events during read-alouds (see Fig. 1 below).

**Dimensions of agency**

Our perspective utilizes the multiple dimensions revealed by previous empirical and theoretical work on agency. The first dimension (*Agency—Passivity*) is concerned with the social positioning of environmental stakeholders, including the teacher, students, and absent others (e.g., animals). In other words, it seeks to clarify the specific experiential roles such as agent and recipient (un)intentionally played by the different parties involved in a particular environmental issue. Like Roth (2007), we use agency to denote a type of experiential role in which acting beings are said to have the capacity to act upon their surrounding environment. Because beings in agentive roles are guided by intentions or goals, they are considered responsible for their actions. Passivity, on the other hand, refers to an experiential role of receptiveness, that is, beings who are simply susceptible to or affected by others’ actions and to whom experiences or events simply happen. Passive recipients are simply objects of others’ actions or impacted by the world (i.e., their experience is unplanned or unintentional), and for this reason have no responsibility over the experienced events.

The second dimension of agency is *Individuality—Collectivism* which is focused on the specific level of authorship and responsibility attributed to environmental activity (i.e., whether an individual person or social group is to be granted credit, blame, or responsibility over environmental action under consideration). Hull (2003) shows how collective agency is constructed through processes that promote diffusion of individual authorship (i.e., prevent precise specification of authorship or attribution of responsibility). Given the

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**Fig. 1** The linguistic emergence of environmental agency during read-alouds
involvement of multiple stakeholders in environmental issues, authorship and responsibility over environmental damage or protection can remain attributed to an individual or it can evolve into a collective problem or effort during read-alouds.

The third and last dimension of agency is Human—Nonhuman. This dimension deals with the identities of agents which can vary from humans (real or fictitious) to a variety of nonhuman entities. As shown by a growing number of studies across several fields, agentic capacity is attributed not only to humans but also pets (Kortenkamp and Moore 2009) and even the landscape itself which has been shown to shape the social conduct of humans (Basso 1996). Such diversity of agents underscores the possibility of nonhuman agency attribution.

**Positioning students as agents**

Pedagogical strategies aimed at positioning students as agents vary widely with school subject. Given the inherent interdisciplinary nature of environmental issues, consideration is now given to the potential of read-alouds to serve as a source of environmental agency in light of practices previously used in science, mathematics, and language classrooms.

Educational researchers identify specific ways science teachers can encourage students to see themselves as agents of change. A salient theme in this literature is that providing students with opportunities to conduct their own inquiries into environmental issues and use their findings to take action is central to the creation of agents of change. Barratt Hacking, Barratt, and Scott (2007) recommend engaging young people in local environmental research, while others emphasize the importance of youth environmental action to engender active forms of citizenship (Schusler, Krasny, Peters, and Decker 2009). Similarly, Aduriz-Bravo (2011) emphasizes that science teachers can empower students and foster a sense of agency by engaging them in argumentation and authentic acts of scientific inquiry wherein students are allowed to co-construct and apply their knowledge of the natural world.

It is also argued that helping students shift from being conversationally motivated to becoming agents of environmental change requires quality opportunities for dialoguing with stakeholders about their findings and time to renegotiate their own understandings and actions. Blanchet-Cohen (2009) emphasizes that students need to move beyond being able to talk about environmental issues to actual action. Similarly, Bigger and Webb (2010) argue that teachers should promote “engaged resisters” in the classroom by encouraging young people to overcome peer pressure and cultures that marginalize environmental activism.

Environmental educators have also emphasized the important role of reading in the promotion of student agency. Reading environmental literature is seen as an effective means to promote intersubjectivity (McKenzie 2008), help students politically understand the world, create dialogue about values and ethics, introduce different perspectives, consider alternative courses of action, and encourage students to reconsider their attitudes and concepts (Bigger 2009). Likewise, David Gruenewald (2008) argues that fictional literature can help increase the sophistication of students’ stances on the environment. By connecting with characters, plots, relationships, dilemmas and places, and being provided with time to re-evaluate and re-negotiate their own opinions, students can begin to question their stance on the environment and ultimately (re)position themselves.
Researchers have also examined math classroom practices that foster student agency. Boaler and Greeno (2000) report that, while didactic teaching practices position the discipline as the authority (i.e., gives it all agency), discussion-based teaching practices position students as active agents who are responsible for constructing their own learning and accountable for the learning of their classmates. Brown (2009) points out that, when classroom practices lead to a shift from agency of the discipline to conceptual agency, students begin to develop a sense of agency in the classroom and view themselves as acting mathematicians. In a similar study, Cobb, Gresalfi, and Hodge (2009) describe how students see mathematics as a tool and feel obligated to themselves for learning in classroom when they are afforded the opportunity to express agency. By contrast, in classrooms where students are restricted to exercising disciplinary agency, they see the teacher as the only authority and feel obligated to produce correct answers.

Math educators with an interest in social justice have also sought to foster student agency. Stinson (2010) shows that successful African American males exercise agency by developing opposing discourses. Gutstein (2007) discusses how math instructors can help develop social agency by structuring instruction in a way that students learn how to use mathematics as a tool to understand social injustices and enact change. He also suggests using problems students are familiar with and linking them to larger social issues to create opportunities for students to develop agency. These researchers point out that helping students view themselves as agents of social change leads to the development of a sense of empowerment.

Developing a sense of agency is also a very important part of language learning. Wassell, Hawrylak, and LaVan’s (2010) point out that classroom structures such as a schema of caring can affect English Language Learners’ (ELLS’) sense of agency, that is, their perceived ability to access relevant resources necessary for meeting their learning goals and social needs. Poor instructional practices such as lack of empathy for students’ experiences and diminished access to the curriculum constitute roadblocks that can hinder students’ learning. Pinnow (2011) discusses the important role of multimodal fluency in establishing agency in the second language classroom. McKay and Wong (1996) relate ELLs’ discourses and identities to their exercise of agency in terms of their positioning in relations of power both in school and American society. Chang and Strauss (2010) underscore the need for academic supervisors to foster ELLs’ agency through the creation of empowering classroom social structures.

The above literature provides compelling evidence that pedagogical contexts conducive to the emergence of student agency (i.e., a personal sense of empowerment) within a content domain are characterized by inquiry and concept application, actual action or pursuit of change, reading, discussion, and validation of one’s personal experiences and sociolinguistic background as an important source of learning and reflection. Central to these agency-fostering practices is the strategic positioning of students within an active footing (Goffman 1981) or social alignment as agents in relation to an audience (peers, outside individuals, etc.) or system (society, the environment, or social group). This is precisely what collaborative, dialogically oriented read-alouds—the classroom practice examined in this study—is designed to accomplish. Pappas, Varelas, Barry and Rife (2002) describe this interactive reading practice as

read-alouds [that] allow for the voices of both children and the teacher in this process. Participants relate, imagine, clarify, validate, encourage, try to make sense, turn to their own and others’ experiences to understand the world and to reveal themselves within it. (p. 473)
Such description suggests that environmentally focused, dialogic read-alouds has the potential to provide elementary teachers with a pedagogical means to cope with societal reproductive loops as well as multiple and often conflicting motivations, beliefs, sociocultural norms, and sociopolitical factors that often underlie environmental issues. In the present study, we examine the extent to which this is indeed the case.

**Methodological design**

In this study, we adopt a case study methodology to examine *environmental agency* in the context of read-alouds. Our methodological choice was informed by Yin (2009) who posits that a case study design should be utilized when one needs to understand a real-life phenomenon in depth and when such understanding encompasses important contextual conditions highly relevant to the phenomenon of study. This is precisely the goal of this exploratory paper which relies mainly on descriptive data systematically collected through open-ended research methods (video-recorded observations) and analyzed inductively to build a naturalistic (Lincoln and Guba 1985) account of elementary teachers' and students' meta-agentive discourse. To achieve this goal, we qualitatively explored each of three cases (distinct teacher read-aloud sessions) separately. Such a methodological approach allowed us to dedicate a fair amount of attention to each teacher's read-aloud and her interaction with the students discussing the environmental books. As emphasized by Patton (2002), “the analyst’s first and foremost responsibility consists of doing justice to each individual case. All else depends on that...[as a result] each case study in a report stands alone, allowing the reader to understand the case as a unique, holistic entity” (pp. 449–450). This approach enabled us to conduct an in-depth exploration without interfering with teachers’ oral literacy practices.

It should be noted that this study does not aim at making generalizations beyond the three cases that are discussed herein. Focusing on a few discreet cases enabled our thorough analyses, not for generalizing beyond the case, but for understanding the complexity of each case (Creswell 2007). This is in line with Yin’s (2009) argument that in analytical generalization through case studies “the investigator is striving to generalize a particular set of results to some broader theory” (p. 43), not a larger sample like in the quantitative paradigm.

We embarked on this study with a view to examining the discursive practices of elementary teachers and their students in read-alouds that also encompassed discussions of environmental issues. According to Patton (2002), a unit of analysis in case studies is usually determined during the design stage and becomes the basis for purposeful sampling. Accordingly, on analyzing transcripts of all participant teachers we selected those read-alouds where teacher–student agentive discourse revealed an interesting dynamic. Such initial findings were considered during our systematic peer-checking sessions and only after unanimous agreement became a unit of thorough analyses.

**Participants**

Using an Albany-area listserv, a survey of science read-aloud practices was sent to elementary teachers in upstate New York. The survey was composed of a series of open-ended questions that asked for demographic information such as years of teaching experience, teacher preparation, school and classroom settings, as well as pedagogical information concerning teachers’ read-aloud practices including frequency of their science
read-alouds, book selection criteria, books commonly read aloud, strategies used to incorporate read-alouds into science instruction, and strategies adopted to ensure science learning during read-alouds. From the pool of respondents, elementary teachers who regularly performed science read-alouds were recruited to be video-recorded while facilitating a science read-aloud session in their classroom. While participation in the project was voluntary, we sought to select teachers that had a wide range of teaching experiences (novices and veterans) and taught in a variety of instructional settings (urban, suburban, and rural areas) and grade levels (1 through 6).

Initial inspection of the resulting corpus of video-recorded data revealed several environmental read-alouds with high degrees of teacher–student dialogism. More specifically, these teachers repeatedly interrupted their aloud reading of the text for short periods of time to facilitate whole-class discussions about environmental issues in the children’s books. These dialogic read-alouds became the central focal point of our analysis, being adopted by three elementary teachers—Carol, Susan, and Andrea—from different schools. All teacher names were changed for this study to ensure confidentiality. Further, the choice of the books for read-alouds was not influenced by the researchers in any manner; all the books were selected by the participating teachers on their own accord.

With 17 years of experience, Carol taught fifth grade to seventeen students at a suburban school. Carol indicated that she often read science trade books, newspapers, and Internet articles to improve her students’ ability to decode and comprehend texts, engage students in topics such as Earth’s climate, and inform students about current issues related to science. Carol was video-recorded while reading the book *The Wolves Are Back* (George and Minor 2008). A description of the contents of this and other books can be found on Table 1.

Susan had 13 years of experience and taught a group of twelve fourth-graders at a suburban school. For her video-recorded read-aloud she selected the book *Why the Ice Caps Are Melting?: The Dangers of Global Warming* (Rockwell and Meisel 2006). Susan read aloud on a daily basis, a practice aimed at engaging and informing her students about current topics relevant to their lives, especially environmental issues.

Andrea had 9 years of teaching experience and taught a group of second-grade students at an urban school. She read nonfictional and colorful books aloud 2–3 times a week as a means “to spark discussion and investigation” and to introduce topics to which her students could relate. For this study, Andrea chose to read aloud the book *Polar Bears in Danger* (Edwards and Johnson 2008).

**Data collection**

Our data set comprised mainly of a digitally captured corpus of video-recordings of classroom observations of each teacher performing a science read-aloud. The video-recordings, which took place during the 2009–2010 school year, were captured with a digital camcorder focused mainly on the teacher. This teacher-centered focus was a direct consequence of the human subject research protocol associated with this study which did not permit video-recording of children’s faces, only their voices. All video-recordings were transcribed in full (see “Appendix” for transcription conventions) and their content examined to determine how teachers and students communicated agency over environmental issues under deliberation.
Data analysis

Our analysis of elementary teachers’ and students’ meta-agentive discourse during environmental read-alouds was guided by a theoretical framework that we developed based on the above literature review and our previous empirical work (Oliveira, Akerson, and Oldfield 2012; Oliveira, Colak, and Akerson 2009). As can be seen on Fig. 2, our framework conceives of environmental meta-agentive discourse as having two important focal points (each represented as a separate and orthogonal axis). The first focal point (Agent-Action-Recipient) is concerned with identifying the beings or entities under consideration. In other words, it seeks to clarify the types of agents taking environmental actions (e.g., humans, animals) as well as the types recipients being environmentally

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Environmental read-aloud</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carol</td>
<td>Duration: 27 min</td>
</tr>
<tr>
<td>Book Title: The Wolves Are Back (George and Minor 2008)</td>
<td></td>
</tr>
<tr>
<td>Book Genre and Stylistic Features: Nonfictional, expository picture book that provides a historical and ecological account of the return of the wolves to Yellowstone National Park. The book narrates how the wolves nearly became extinct around 1926 when the directors of national parks in the US decided to eliminate “non-gentle animals,” a decision that inadvertently produced an ecological imbalance at Yellowstone and was eventually revoked in 1995. The book focuses mainly on how the return of 10 adult wolves from Canada has a positive ecological effect on the parks’ wild plants and animals (birds, Bison, bears, beavers, insects, elks, deer, antelopes, badgers, etc.), restoring the overall ecosystem to a state of natural balance. The book contains highlight detailed and naturalistic descriptions and scenes (landscape paintings) meant to inspire and encourage students to reflect about the beauty and wonders of natural wilderness at Yellowstone Park</td>
<td></td>
</tr>
<tr>
<td>Susan</td>
<td>Duration: 19 min</td>
</tr>
<tr>
<td>Book Title: Why the Ice Caps are Melting?: The Dangers of Global Warming (Rockwell and Meisel 2006)</td>
<td></td>
</tr>
<tr>
<td>Book Genre and Stylistic Features: Nonfictional, expository picture book that includes cartoonish representations of pristine nature (e.g., drawings of wild penguins on icebergs, polar bears on glaciers, etc.), environmentally harmful human activities (e.g., landfills, urban traffic, deforestation,), scientific inscriptions (e.g., a diagram of Earth’s greenhouse effect), and expository/factual texts. Most of the book focuses on describing how each environmentally harmful human activity increases the amount of greenhouses in the atmosphere which in turn produces global warming with disastrous consequences such as flooding, desertification, and spread of invasive species. The book then ends by identifying a series of measures (e.g., planting trees, saving energy, riding bikes, and taking political action) to help mitigate the problem of global warming</td>
<td></td>
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<tr>
<td>Andrea</td>
<td>Duration: 20 min</td>
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<tr>
<td>Book Title: Polar Bears in Danger (Edwards and Johnson 2008)</td>
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<td>Book Genre and Stylistic Features: Nonfictional, expository picture book that includes cartoonish representations of pristine nature in the Arctic (e.g., drawings of polar bear in the wild), scientific inscriptions (e.g., a diagram of Earth’s greenhouse effect), and expository/factual texts. The book is composed of two main parts. The first part is designed to inform students about several aspects of the life of wild polar bears (e.g., hibernation, hunting of seals, size, offspring, shelter, physical ability, etc.). In sharp contrast, in the second part of the book, the focus suddenly shifts to a variety of human activities (offshore oil rigs, busy highways, electricity consumption, farming, hunting, etc.) that not only pollute the environment but also cause global warming by thickening the layer of greenhouses in the atmosphere. The book then ends with a description of the suffering and hardship befallen upon polar bears (e.g., starvation and drowning) as a result of anthropogenic global warming which in turn leads polar bears to come dangerously close to human dwellings</td>
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affected (e.g., animals, inanimate elements of nature). Also pertinent to this first focal point is whether the beings or entities involved are real, imaginary, individuals, or collectives. The second focal point (Intentions-Action-Outcomes) deals with what the beings or entities under consideration have done or will do (i.e., the specific environmental actions taken) as well as the intentions (e.g., nature protection, financial gain) and outcomes (e.g., beneficial or harmful) of their environmental actions.

As part of the above analysis, we constructed visual representations of environmental agency in read-aloud discourse. Construction of these visual representations entailed systematic adoption of several symbolic elements which we use to represent specific aspects of agential cognition as revealed by our review of the scholarly literature. Venn diagrams are used to represent the human relationship with nature (Kahn 1999) as two separate, yet overlapping worlds. Such representational choice is consistent with psychological research showing that central to human cognitive and social development is the gradual recognition of the differentness or other-ness of the natural world (e.g., animals) as nonhuman and hence distinct from the human self (Kellert 2002). It is also reflective of philosophical stances on modern science as based on a separation of human from nature (Orr 2002) as well as Myers and Saunders’ (2002) argument that “animals [and nature more broadly] may be social others to us with whom we [people] can form relationships” (p. 154). Clipart images are used to identify the main agents and recipients of environmental actions considered within each read-aloud discussion. Solid arrows are used to represent agentive environmental action wherein an agent (identified as the cause and the one responsible for such action) produces outcomes that directly and proximally affect others (recipients), that is, events with a single proximal cause (Choi et al. 2003). Dotted arrows are used to represent ripple effects which Maddux and Yuki (2006) define as “downstream effects of actions and events, particularly those effects that are relatively

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**Fig. 2 Framework for analyzing environmental agency during read-alouds**

- **AGENT** (Individual or Collective)
  - Human (self or other)
  - Non-human (animals, fictional characters, etc)

- **INTENTIONS**
  - Nature protection
  - Financial gain

- **ENVIRONMENTAL ACTION**
  - Takes
  - Leads to
  - That affects a

- **RECIPIENT** (Passive Being or Thing)
  - Animal
  - Inanimate nature (plant, ecosystem, etc)

- **OUTCOMES**
  - Beneficial to humans
  - Harmful to animals
indirect and distally related to the focal event… [wherein] attention is directed toward the broader context and toward the interrelationships among individuals and events” (p. 671). As such, solid and dotted arrows allow us to distinguish between *intentional action* (motivated by an intention or goal) from *accidental action* (unintended effects or consequences) (Filipovic 2007).

**Agential Attribution in Read-Alouds**

We now describe the observed patterns of agential attribution in each read-aloud.

The wolves are back

While the book focused primarily on the ecological relationships between wolves and other animals native to Yellowstone Park, classroom discussion centered on the human–wolf relation. During this discussion, Carol and her students constructed two distinct types of agential relations, namely human as agents of ecological balance (symbolized by solid arrow 1 on Fig. 3) and wolves as agents of unhappiness (symbolized by solid arrow 2 on Fig. 3). These are described and illustrated below.

*Humans as agents of balance*

This particular agency emerged at the onset of the whole-class discussion that followed Carol’s aloud reading of the book. Carol began this discussion by quickly summarizing the book and then prompting students to share their interpretations and to comment on the book. The following exchange ensued:

![Environmental Agency in The Wolves Are Back](image-url)
Carol: They [people] removed the wolves, and eventually… the wolves were brought back into our country from Canada… the sparrows came back once the wolves came back because they [sparrows] had the grasses that they needed for their food and for their nests, and before, they didn’t because of the elk… so this page is sort of summarizing… how the balance in Yellowstone is back again and things are flourishing again. That’s the end… so tell me, what do you think Jean Craighead George [author] wants you to take away from reading this book?

Students: Things can hurt our environment and our world. Taking one animal away is taking many animals away.

Carol: Ok, very good. So there’s a balance to be kept, isn’t there? And when you [humans] take away one species, it can affect the balance of the area of all the other animals, birds, insects, and so forth.

Throughout the above discussion, humans are portrayed as the agents responsible first for the removal and later for the return of the wolves (recipients of both actions) to Yellowstone Park. As the discussion unfolds, the second environmental action is then described as having a positive environmental impact on the park’s ecosystem, leading to a considerable reduction in the overgrown elk population (a direct beneficial outcome) which in turn causes “sparrows to have grasses needed for food and nests” and “things to flourish again” (indirect beneficial outcomes). As result, humans are constructed as external causal agents of ecological (im)balance, that is, organisms that, although not part of the park’s natural ecosystem, have the power or capacity to restore the dynamic state of equilibrium that naturally exists in the population size, food supply and shelter available to a group of interdependent animals within a natural ecosystem such as Yellowstone. Such agential construction of humans does not take into account intentionality as no consideration is given to whether restoration of ecological balance was actually intended by those who decided to bring the wolves back to Yellowstone or just an accidental outcome of such environmental action, which is described in the book as simply due to visitors’ yearning for the wolves’ howling and public outcry in face of evidence of wolves’ non-aggressive behavior toward humans.

**Wolves as agents of unhappiness**

A different type of agency emerged toward the end of the whole-class discussion when Carol encouraged students to recognize that different human groups may have different perspectives or opinions about the return of the wolves to Yellowstone Park by humans:
Carol: Do you think anybody is unhappy that the wolves are back? Do you think some people are not too happy? What people might not be too happy that the wolves are back? What kind of animals do wolves sometimes kill that people might be concerned about? How about ranchers? What kind of animals do they have that the wolves might attack?

Student: Like cows.

Carol: Like cows. Yeah, exactly.

Student: Maybe horses?

Carol: Maybe horses. Sheep.

Student: Could have been a fox, maybe.

As shown above, Carol encourages students to consider the same environmental action (returning the wolves to Yellowstone) from the perspective of “unhappy” humans. To do so, she prompts students to recognize that the wolves’ return can lead to the attack of livestock such as cows, horses, and sheep (a direct harmful outcome) which in turn can make interested humans such as ranchers unhappy (indirect harmful outcome). As a result, wolves are constructed as direct agents of attacks against domesticated animals as well as indirect agents of human unhappiness. Once again, intentionality of those involved (ranchers, visitors, rangers, park directors, and wolves) is not addressed, that is, whether such attacks constitute accidental and unintended events is not taken up as a topic of discussion.

Why are the ice caps melting?

The aloud-reading and discussion of this book centered on the human relationship with Earth’s atmosphere. Discursively encoded in this read-aloud were two different types of agency, namely humans as agents of atmospheric imbalance (symbolized by solid arrow 1 on Fig. 4) and humans as agents of environmental mitigation (symbolized by solid arrow 2 on Fig. 4). These are described and illustrated below.

**Humans as agents of imbalance**

This first type of human agency emerged throughout the read-aloud when Susan and students repeatedly interspersed aloud reading with comments and short exchanges wherein humans were invariably ascribed the role of causal agents of harmful action to the environment such as pollution and deforestation:
Susan: Are we doing good things or bad things to our Earth right now?

Students: Bad things, bad things

Susan: Some bad things... we have a lot of people living on Earth, don’t we? Yeah, lots. And we’re not all necessarily thinking about what’s best for thing for Earth, we’re thinking about what’s easier for us, I’m guilty of it, and I’m sure all of you are, we think about what’s easier for us or us to do and use, not the Earth... today these forests are being cut down to make lumber for houses and other building and wood pulp for paper...

Students: My dad cuts down trees [inaudible].

Susan: Last year [we] talked about South America, so you are well aware of the Amazon and the trees being cut down.

As underscored above, a sense of collectivistic agency pervades the above exchanges wherein the teacher herself, students and even their parents are attributed shared responsibility and blame for the “bad things” (harmful environmental outcomes) befalling upon the planet Earth at large (recipient). While the book itself focused mainly on describing distal and indirect consequences of varied types of human action (e.g., how driving cars leads to the thickening of the greenhouse gas layer which in turn leads to warmer global temperatures which then leads to glacier melting which finally leads to flooding), Susan facilitated discussions more focused on identifying the agents causing global warming. This shift in attention toward agents who might be considered “culprits” has been shown to have important implications for how much people are inclined to blame others (Fausey et al. 2010). By admitting to her own share of responsibility over Earth’s atmospheric imbalance and encouraging students to acknowledge theirs, Susan discouraged students from simply “blaming others” and instead recognize that they also shared responsibility over the rippling effects of global warming, which are often felt halfway around the globe.
As a result, agentivity over atmospheric imbalance is constructed as a morally wrong environmental outcome that can be distally and indirectly blamed on humans in general irrespective of their intentionality (not explicitly considered in the above discussions).

**Humans as agents of mitigation**

This second type of human agency emerged toward the end of the read-aloud when attention shifted away from harmful human activity causing atmospheric imbalance to environmentally responsible action that the students themselves could take to mitigate the problem of global warming:

Susan: What can you and I do to help? We can plant trees. We can stop using aerosol spray and use pump sprays instead. We can buy appliances that are designed to use less energy and tell us that by the seal pasted on them. We can walk or bicycle to places that aren’t far away. We can write letters at home and at school to representatives in Congress, telling them that we think global warming matters. So you think we can try that possibly?

Students: Say um, that you just keep planting trees, isn’t it still going to get warmer since we’re all living, isn’t it just gonna get warmer but warmer slowly?

Susan: As long as we’re maybe slowing the effect down, we’re helping. We’re just a small part of the big Earth, but any little bit will help.

As underlined above, Susan identifies herself and the students as agents with the capacity of “planting trees,” an environment action meant “to help” with the problem of global warming (intended beneficial outcome). However, in their reactive comments, students appear to deny or question this agency Susan attributes to them by pointing out that the action “planting trees” will not directly and proximally cause the outcome “elimination of global warming” as implied by Susan and the book. It is important to note that, unlike the previous account of environmentally harmful action (described as broad and complex causal attributions with indirect and distal consequences to the atmospheric balance and global nature), the environmentally responsible action of planting trees is framed as a direct and proximal causality, which students appear to recognize to a certain extent as being simplistic. Instead of elaborating on the rippling effects of such beneficial action to Earth’s climatic system (e.g., contributing to the reduction of CO₂ in the greenhouse layer), Susan immediately redefines the intended outcome “helping” as “slowing down a little” (as opposed to “completely eliminating”) global warming. Put differently, while causation of global warming is problematized in terms of anthropogenic imbalance of the Earth’s atmosphere, prevention is simplified and reduced to isolated and uncoordinated acts of mitigation such as planting a few trees.
Polar bears in danger

This read-aloud centered on the relationship between humans and polar bears in the Arctic. In it, three different forms of collective agentive expression were verbalized by Andrea and her students: humans as indirect agents of endangerment (solid arrow 1 on Fig. 5), humans agents of prevention (solid arrow 2 on Fig. 5), and humans as indirect agents of endangerment (solid arrow 3 on Fig. 5).

**Humans as agents of endangerment**

Throughout this read-aloud, humans were repeatedly identified as active agents whose actions posed a threat or danger to the survival of polar bears (both directly and indirectly). Direct endangerment originated from practices such as hunting, whereas indirect endangerment was associated with anthropogenic global warming. While the book focused mainly polar bears in nature (interactions with cubs and seals in the wild), classroom discussion centered on the human–bear relationship:

Andrea: They have one enemy, who do you think that enemy is of the polar bear?
Students: Shark, an Arctic fox, a hunter.
Andrea: A hunter, man is the only danger to the polar bear [reading] people. In the past, polar bears were hunted for their meat and for their fur. In more recent times, hunters went after them for sport. People like to shoot things... perhaps the greatest danger to polar bears comes from global warming...If the worlds temperature gets warmer, what's one of the dangers for polar bears?
Students: The polar bears will get too hot. They might melt.
Andrea: The polar bears will get too hot and die.

As can be seen above, humans are identified as the sole agent actively responsible for environmental action leading to the death of polar bears (recipients). Such harmful outcome is produced directly by means of the intentional activity of hunting, which is depicted as serving varied purposes such as providing food (“for their meat”), clothing (“for their fur”), or simply entertainment (“for sport... people like to shoot things”). Another anthropogenic source of polar bears’ lethal demise is global warming which, like in the previous read-aloud, is described in the book as being distally and indirectly caused by humans through environmentally detrimental action (e.g., overconsumption of electricity, and clearing of forests) with a series of rippling effects, including the thickening of the greenhouse gas layer which produces warmer global temperatures that lead to the melting of the ice in the Arctic which then negatively impact the polar bears’ ability to feed, “forcing” them to eat fish and berries and to “go near people’s homes” (instead of hunting seals in the wild). Unlike the wolves in the first read-aloud, polar bears are not attributed agency over their “invasion” of the human world (as agents of endangerment to humans).
which is instead depicted as simply a rippling effect of anthropogenic global warming for which humans themselves are responsible, not the polar bears.

**Humans as agents of prevention**

This third and last type of human agency was limited to the very end of the read-aloud when attention shifted away from how global warming negatively impacted polar bears to environmentally responsible action that the students themselves could take to stop or prevent the problem of global warming:

Andrea: What’s one way you can help prevent that? One way?
Students: Umm, if I’m not using my TV, I turn it off. We aren’t really allowed to watch TV. Everyone in my family is allowed to watch one show a day
Andrea: Ok, so you shut your TV off
Students: Umm, in the morning, before the day breaks my mom [inaudible]
Students are identified agents with the capacity of actively addressing the problem of global warming through the environmental action such as saving energy (“turning the TV off”). However, this time the intended beneficial outcome is to prevent or stop global warming (as opposed to partial mitigation). Put differently, “helping” is now defined as making a contribution toward the goal of “completely eliminating” global warming (as opposed to “slowing it down a little”) through a collective effort. Two other noticeable differences are the absence of agentive denial by students and the unemployment of the notion of “balance.” Nonetheless, the environmentally responsible action of shutting the TV off is once again reduced to a direct and proximal causality with unelaborated rippling effects (e.g., contributing to the reduction of CO₂ in the greenhouse layer). Like mitigation, prevention of global warming is simplified and reduced to a few environmental acts largely disconnected from the Earth’s climatic system.

Agents, Causes, and the Balance of Nature

In this section we draw theoretical and empirical connections between our findings and the existing scholarly literature.

Human agency

As described above, across the read-alouds, humans were simultaneously attributed negative agentive roles (agents of endangerment and imbalance) and positive agentive roles (agents of prevention, mitigation, and balance). Such seemingly contradictory patterns of agentive attribution suggest an inherent tension between morally negative and positive human agency with regard to environmental action. On one hand, human action was constructed as being driven by selfish human intentions or goals (e.g., eliminating animals to avoid financial loss, polluting for personal convenience, and killing animals for fun) that led to negative outcomes (e.g., loss of preserved wilderness, flooding, and animal attacks) affecting not only nature but also other humans. On the other hand, human acts were depicted as being altruistically motivated, that is, aimed at producing unselfish outcomes such as restoring wilderness for park visitors, avoiding flooding, and preventing animal attacks on humans.

Such tension is consistent with recent philosophical and theoretical arguments emphasizing the centrality of conflicting goals or intentions to human moral agency. As Wallach and Allen (2009) write,

A central feature of the human experience as moral agents is that people frequently feel poised between acting selfishly and acting altruistically. People feel the pull in both directions and this tension sets up the possibility of freedom – the equal freedom to do the wrong thing or the right thing (p. 61)

It is precisely this sort of moral agency that teachers expressed when describing the ripple effects of environmentally irresponsible action back to other humans while reading-aloud. By focusing on the harm being distally and indirectly caused to other humans, students were encouraged to recognize the wrongness of such selfish environmental action. For instance, presumably unintentional acts such as leaving the TV on were portrayed as wrong for (indirectly and distally) causing polar bear attacks on humans in the Arctic. Such
portrayals served to improve students’ ability to assess the moral significance of seemingly insignificant and routine acts, thus fostering their sense of moral agency as individuals capable of doing the right thing for the sake of other human beings (i.e., altruistic reasons).

Another important aspect of agential attribution to humans is power. This became particularly evident when Susan’s students questioned their ability to effectively act as agents of mitigation of global warming. Their statement “say that you just keep planting trees… isn’t it just gonna get warmer but warmer slowly?” suggests a lack of environmental agency, that is, a disempowered personal perception as individuals who are incapable of taking significant action to address this particular environmental problem. Underlying this statement of disempowerment is type of thinking rooted in essentialism (Lakoff and Johnson 1999) which is reflected in the students’ suggestion that “planting trees essentially makes no difference as the Earth will continue to get warmer.” Such student reaction highlights how increasing one’s awareness of the larger rippling effects of environmentally detrimental actions can, at least initially, foster a sense of disempowerment (a feeling of being too small and insignificant given to make a difference at a larger global scale). As illustrated by Susan’s comment “any little bit will help,” disrupting this problematic way of thinking about environmental issues requires clarifying the importance and significance of localized personal action, small as it may seemingly be, to the larger scheme of things. A similar strategy is used in the environmental documentary Waste Land where Valter dos Santos, a garbage picker who works in a Brazilian landfill, utters “99 is not 100” to eloquently make the point that recycling even a single can is central to improving society at large. Like Susan’s, Valter’s comment effectively disrupts essentialist ways of thinking about environmental action by highlighting the importance of an isolated act (highly symbolic in nature) to the larger goal of mitigating environmental pollution. In both instances, the speaker’s rejection of essentialism produces a highly empowering message regarding human agency in the context of extensive and complex environmental systems.

Animal agency

Another interesting finding was the differential patterns of agency attribution to wild animals such as wolves and polar bears. It was particularly noticeable to us that, while the returned wolves at Yellowstone Park were constructed as intentional (human-like) agents when they crossed over into the human world to kill livestock in nearby farms, polar bears in the Arctic were denied any form of agency when they approached people’s home in search for food. Put differently, wolves were held responsible for their killing of livestock and the resulting unhappiness of ranchers, whereas polar bears were not attributed any sort of accountability for placing people at risk.

Such differences in agential attribution by elementary teachers and students suggest an emphasis on external aspects of agency when it comes to making sense of wild animals’ behavior or action. As emphasized by several philosophers and theorists, the notion of agency presupposes the possibility of freedom of choice as well as the ability to overcome external constraints (Kant 1949) or opposing environmental forces (Morris et al. 2001). To qualify as an agent responsible for a given course of action, a being must be able to choose among multiple options as well as be able to counter environmental forces. A similar point is made by scholars who emphasize the importance of taking into account degree of freedom in considerations of moral agency (Denett 2003). As Wallach and Allen (2009) write, “maximization of choice is central to moral agency” (p. 62) From this perspective, it can be argued that elementary teachers and students’ attribution of agency to the wolves was likely related to an underlying perception of wolves’ freedom in making their kills—
the wolves had the option of killing wild animals such as elks but instead chose to attack livestock, thus being, to a certain degree, morally responsible for such acts. By contrast, polar bears’ approach of human homes was conceived as a ripple effect, a distal and indirect consequence of the environmental constraints of global warming (e.g., inability to hunt seals), for which humans themselves were responsible as causal agents. Such reduced freedom of choice explains the apparent lack of agential attribution to polar bears during read-alouds.

At a cultural level, the above finding suggests differences in values toward polar bears and wolves. As emphasized by Kellert (1996, 2002), depending on their cultural background, people can develop different values of nature (i.e., tendencies to associate or affiliate with nature in certain ways). These values play a central role in shaping the human relationship with nature and can be shaped by social representations (Lopez-Facal and Jiménez-Aleixandre 2009) and cultural images (Melson 2001) to which children are exposed. For instance, cultural images such as the “Big Bad Wolf” (in children’s stories) and “starving polar bears” (in public service announcements) figure prominently in American culture and can provide people with vilified social representations of wolves and victimized social representations of polar bears. Such cultural background can affect people’s personal values and reasoning about socioscientific issues involving wolves (Jorde and Mork 2007) and bears (Simonneaux and Simonneaux 2009). Moreover, current psychological research (Fausey et al. 2010; Fausey and Boroditsky 2010) shows that linguistic cues to agency in the description of events have serious consequences for people’s perception and memory of events (as accidental versus intentional) and how much people blame and punish others. Therefore, our finding underscores the need for environmental educators to carefully consider the particular values of animals being reinforced or challenged through implicit agentive communication during read-alouds as this may inadvertently shape students’ tendency to blame or punish certain animals such as wolves.

The balance of nature

A common theme across all three environmental read-alouds was the balance of nature, a notion repeatedly used as a justification for environmental conservation. In The Wolves Are Back, humans were portrayed as restoring ecological balance to Yellowstone through the reintroduction of wolves. Likewise, both Why the Ice Caps are Melting? and Polar Bears in Danger focused on humans’ role in altering the environment and causing global warming, as well as the need for humans to intervene to discontinue the damage being caused. However, the extent of human intervention differed in these two read-alouds. In Why the Ice Caps are Melting?, it was suggested that humans could only mitigate the damage being done to the environment, whereas in Polar Bears in Danger it was proposed that humans could prevent such damage and restore the balance of nature to its pre-human state.

Such finding is consistent with previous research revealing the popularity of the “balance of nature” in environmental conservation arguments. However, use of such metaphorical notion has been criticized by researchers such as Ladle and Gillson (2009) who argue that the “balance of nature” metaphor is problematic because it provides a simplistic and static representation of ecological systems, which does not reflect the complexity and instability of real ecosystems. Zimmerman and Cuddington (2007) note that science students do not have a fixed definition for the balance of nature, are unable to make a distinction between the concept and its causes, and often perceive the balance of nature as a real phenomenon rather than a metaphoric or poetic description of ecological systems. Similarly, in the three read-alouds examined in this study, discussions of the balance of nature evoked a definition of balance as equilibrium. However, none of the read-alouds
made a clear distinction between the notion of balance and its cause. It seemed clear from the discussions that humans could affect the balance of nature, either through absence of disturbance (*The Wolves Are Back*) or direct disturbance either positive or negative (*Why the Ice Caps are Melting?* and *Polar Bears in Danger*), but the balance of nature was treated as inherent to ecosystems (i.e., its cause remained unknown). As the above research shows, although the *balance of nature* metaphor can be helpful, this metaphor can also be problematic for teaching about the environment. Such potential, we believe, underscores the need for elementary teachers to reflect more carefully and critically about their metaphorical choices, and consider more dynamic alternatives such as the *flux of nature* (Ladle and Gillson 2009) and the *tipping point* (Gladwell 2000).

Agency as rational causality

Another important outcome of our exploratory examination of elementary teachers’ and students’ meta-agentive discourse was the emergence of different forms of environmental causality or *causal models* (Grotzer and Perkins 2000) across the two read-alouds on the topic of global warming (*Why Are the Ice Caps Melting?* and *Polar Bears in Danger*). As indicated above, anthropogenic causation of global warming was constructed as distal and indirect chains of cause and effect (i.e., sophisticated sequences of ripple effects), whereas its mitigation and prevention assumed the form of simple and unidirectional causative links (direct and proximal causality). Such a finding underscores the rational dimension of agency (as causality), being consistent with Lemke’s (1990) semantic perspective on agency as being grammatically expressed in science talk as a logical relationship of transitivity between an *Agent* (an entity that performs, causes, or instigates an action) and a *Process* (the performed action).

The above finding suggests a potentially problematic pattern of asymmetric causal reasoning. Previous research has shown that simplified causal models can lead to oversimplified interpretations of complex systems and thus fostering student misconceptions. As Grotzer and Perkins (2000) write, “while simplified [causal] models may work for many aspects of explanation in our lives, they can also distort the scientific information to the point where parts of the causal story are lost or misconstrued” (p. 3). Moreover, students have been previously shown to commonly overlook long-term and indirect consequences of ecological actions and decisions (Hogan 2002) and often lack the complex system thinking skills needed to infer nonlinear and indirect forms of causality (cyclic, domino, mutual, probabilistic, emergent, etc.) within ecosystems (Grotzer and Baska 2003). More specifically, difficulty in understanding global warming has been attributed to people’s *reductive biases* (Feltovich, Spiro, and Coulson 1993) such as their tendency to overlook processes with multiple, decentralized, non-obvious, and cumulative causes that involve temporal delays, spatial gaps, and no intentional agency (Grotzer and Lincoln 2007). Therefore, it can argued that elementary teachers need to give more careful and critical consideration to the practice of providing students with simplified causal models of human mitigation and prevention of global warming during environmental read-alouds.

Agency as emotionality

Our findings also illuminate sociocultural aspects of environmental agency such as emotionality. Such an emotional dimension was particularly apparent in the visual and textual design of the three books selected by the teachers for their read-alouds. *The Wolves Are Back* contained naturalistic descriptions and scenes (canvas-like paintings of the
landscape) meant to inspire and encourage students to reflect about the beauty and wonders of nature at Yellowstone park. In sharp contrast, both Why Are the Ice Caps Melting? and Polar Bears in Danger included mainly cartoonish representations of nature, scientific inscriptions (diagrams), and expository/factual texts designed to inform students about the destruction and suffering being caused by humans on wild animals, fellow human beings, and the planet at large.

The above differences suggest distinct emotion-based approaches to the development of student environmental agency. Aloud reading of The Wolves Are Back served to promote environmental agency by means of an inspirational environmental story designed to foster students’ emotional affinity to nature (Kals, Schumacher, and Montada 1999), that is, to encourage them to experience positive emotions such as love of nature, and freedom, safety and oneness with nature. Such positive emotional approach served to inspire students to become stewards of the delicate balance of nature (i.e., agents of environmental balance).

A remarkably different emotional approach was taken by the other two teachers during the other two read-alouds (Why are the Ice Caps Melting? and Polar Bears in Danger) which were aimed primarily at developing elementary students’ environmental agency by means of instigating feelings of emotional indignation—responsibility-related emotions such as self-blame due to insufficient nature protection by oneself, indignation about insufficient nature protection by others, and anger toward negatively evaluated nature-protective measures (Kals et al. 1999). By promoting a sense of collective agency during whole-class discussions about ecological responsibility wherein students were positioned alongside the rest of humanity as agents of imbalance and endangerment, the teachers encouraged students to perceive themselves as part of the environmental problems under deliberation and hence experience negative emotions such as self-blame and guilt.

We began this paper by arguing that the existing scholarly literature suggests a tendency among environmental educators to analytically separate student rationality from emotion, and grant primacy to reasoning and argumentation while overlooking students’ emotionality and emergent sense of environmental agency. This analytical disconnection between student reason and emotion presumes the educational preparation of “rational actors” whose environmental actions (thinking and decision-making) are treated as mostly instrumental rather than expressive (Parsons 1951). However, such theoretical stance on the mind (Mead 1938) is inconsistent with the empirical findings and theoretical arguments of a growing number of philosophers, social scientists, and computer scientists (Wallach and Allen 2009). Neurological research shows that human rationality and decision-making are dependent on emotions, more specifically emotion centers of the brain (Damasio 2003) and the biochemical mediation of emotions via peptides (Pert 1995). Based on this neurological evidence, Capra (1996) argues that “human decisions are never completely rational but are always colored by emotions” (p. 275). A similar point is made by the sociologists Turner and Stats (2005), who state that “human rationality is [simply] not possible without emotion” (p. 271). From this perspective, the widely accepted separation between emotionality and rationality is merely a historical artifact, and being emotional is not simply equivalent to being irrational. The present study sheds some light on this theoretical conundrum by highlighting how the construct of “agency” enables systematic analysis of both emotional and rational aspects of environmental classroom discussion, thus constituting a significant theoretical advancement in our present understanding of how the human relationship with nature is (re)shaped in instructional settings.
Limitations and significance

It should be noted that the present study is limited in significant ways. One important limitation is that the collected data does not allow us to examine how the reported patterns of agential attribution affected students who participated in the environmental read-alouds. Although our findings reveal how agency can be orally expressed a variety of ways in the pedagogical context of environmental read-alouds, our analytical efforts fall short of empirically documenting the impact of such varied agential expressions on learning outcomes such as students’ climate literacy (USGCRP, 2009) or their views and values of nature.

Other important limitations include the relatively limited degree of dialogism and scope of our dataset. Read-aloud discussions were sometimes dominated by teacher verbal moves with only fairly truncated responses from the students. Despite their high degree of teacher–student interactivity, these discussions did not always lead to student articulation of personal ideas and perspectives. As such, the environmental discussions to a certain extent fell short of constituting exemplary instances of dialogically oriented pedagogical events. The present study also has a fairly limited scope, focusing on aloud reading of only three environmental books by distinct teachers. Lastly, further analytical consideration will need to be given to the degree to which discursive expressions of environmental agency are contingent upon and reflective of the specific types of texts being read-aloud (i.e., how oral expressions of agentivity relate to written expressions of environmental agency in teachers’ book selections).

Despite these limitations, we believe that the present study has both theoretical and practical significance. With regard to its theoretical significance, the reported findings can serve as a basis for proposing theoretical connections between classroom discourse and environmental behavior. For instance, our findings point to a potential link between one’s sense of personal empowerment and expressions of causality in environmental discussions. Though consistent with previous research showing that diverse conceptualizations or structures of causality typically underlie human causal reasoning (Lakoff and Johnson 1999), such theoretical link will need to be further examined and empirically substantiated by future research.

At a practical level, the finding that environmental read-alouds contain a variety of grammatically encoded expressions of agency (both empowering and disempowering) underscores the importance of increasing school teachers’ awareness of implicit discursive messages in particular patterns of agency attribution when discussing environmental issues with students and implementing pedagogical strategies centered on oral deliberation such as read-alouds. There is also a need for environmental educators who set out to promote student agency to expand the focus of their instructional efforts beyond rational argumentation and reasoning around environmental dilemmas or socioscientific issues. Rather than simply adopting the linear process of “argumentation to action” typically assumed by predominant cognitive models of environmental education wherein agency is simply reduced to rationality (i.e., a matter of reason and logic), educators also need to take into account more complex sociocultural aspects of the human relationship with nature such as emotionality; how one acts toward nature is contingent upon not only what one knows but also how one feels about the environment. This systematic integration of rationality and emotionality is likely to provide environmental educators with a powerful approach to effectively promote students’ sense of environmental agency and (re)shape their relationship with nature.
Appendix: transcription conventions

The following notation is adopted in all transcripts excerpts included in the present manuscript:

? indicates rising intonations
. indicates falling intonations
[ ] indicates observer comments
underlining indicates key linguistic features of the provided excerpts

References


Author Biographies

Alandeom W. Oliveira is an assistant professor of science education at the State University of New York at Albany. He earned a Master’s degree in science education at Southeast Missouri State University (2002) and a Ph.D. degree in science education at Indiana University Bloomington (2008). He has taught science education courses to teachers in Brazil and the US and has coordinated multiple professional development programs for school teachers, including Science Modeling for Inquiring Teachers Network, and Technology-Enhanced Multimodal Instruction in Science and Math for English Language Learners. His research interests include cooperative science learning, inquiry-based teaching, and classroom discourse and language use.

Patterson Rogers is currently pursuing a doctorate in Curriculum & Instruction at the University at Albany. She holds a master’s degree in mathematics from Virginia Tech and in curriculum and instruction from Radford University. Her teaching experience includes college level mathematics and mathematics education courses, as well as STEM related special programs for middle and high school students. Her research focuses on mathematical discourse and how students internalize knowledge created through shared activities.

Cassie F. Quigley is an Assistant Professor in Teacher Education at Clemson University. She earned her doctorate in Curriculum and Instruction at Indiana University. Her research interests include understanding how students acquire scientific discourse through the utilization by blending home and school discourses to provide equitable instruction particularly for urban students. Additionally, she works in the areas of environmental education to empower students and communities to be a part of science. She teaches environmental education and science methods in the Middle Years Masters of Arts Program at Clemson University. Additionally, she teaches advanced Qualitative Inquiry courses for the School of Education.

Denis Samburskiy received an M.S. in TESOL and is pursuing a Ph.D. in Curriculum and Instruction at State University of New York at Albany. His research interests include ESL/EFL instruction, cognitive linguistics and computer-assisted language learning. He teaches a course ‘Corpus-Informed Pedagogical Grammar of English’ and runs an evening ESL program for adults at the university. Denis came to the USA as a Fulbright scholar from Russia in 2007, after graduating from Tomsk State University with a degree in Cross-Cultural Communication and EFL pedagogy.

Kimberly Barss is a doctoral student at Capella University. She completed her Masters of Science in Curriculum Development and Instructional Technology at the University at Albany (2012) where she worked under Alandeom Oliveira. She also received her Bachelor of Science from SUNY College at Brockport and has served as an assistant professor and department chair at Mildred Elley, a small private college in Albany, NY.

Seema Rivera is an adjunct professor of science education at the State University of New York at Albany. She earned her Master’s degree in adolescent education for science at The College of Saint Rose (2005) and a Ph.D. degree in science education at the State University of New York at Albany (2013). She has taught high school chemistry and middle school science in New York State and science education courses to teachers. Her research interests include the nature of science, classroom discourse and methods of teaching science.
The many faces of agency

Walter Doyle

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Abstract This forum article is a response to the paper by Alandeom W. Oliveira, Patterson Rogers, Cassie F. Quigley, Denis Sambursky, Kimberly Barss, and Seema Rivera, Environmental agency in read-alouds. The paper explores agency from the perspective of both personal action and an understanding of causality within environmental systems, both of which are seen as being situated within sociocultural narratives. The authors also link these ideas of agency to environmental read-alouds, which are seen as pedagogical events with the potential to enhance elementary school students’ climate literacy and promote their environmental activism.

In my response, I expand this discussion of agency by examining additional windows on the idea of agency as an educational outcome and as an ingredient of classroom teaching. The first window involves seeing environmental education as an instantiation of prevention education.

Keywords Agency · Prevention education · Classroom tasks
education to see what can be learned about agency from this perspective. The second view turns to the ways in which agency operates within both pedagogical theory and classroom task systems and how an understanding of this dynamic can inform our expectations about the consequences of environmental education. In both of these analyses, the emphasis is placed on sharpening our perceptive on the challenges of praxis in environmental learning.

**Agency in prevention education**

Like “authenticity” and “rigor,” “agency” is one of the big ideas in contemporary discourse about curriculum and teaching. In particular, agency is a core theme in environmental education, reflecting a fundamental commitment to action if not activism as an important outcome for environmental programs. It is not sufficient that students just come to know about environmental dynamics and issues but rather that they become competent and motivated to engage in practical, personal action to address these issues.

To the extent that environmental education seeks to affect personal action, that is, to develop agency, it shares a common ambition with various forms of prevention education that focus on such topics as drugs, violence, smoking, and the like. Reading reviews of research on the effectiveness of prevention efforts, however, is not always encouraging (Gottfredson and Gottfredson 2002). Program effects are frequently difficult to measure and many criterion assessments rely on proxies such as attitude measures or self-reports of actions rather than direct measures of personal practices. And the closer measures get to effects on the actual behavior of participants, the less robust the results seem to be. A similar pattern can be seen in the area of financial education, which seeks to help people become positive agents in their own financial behalf. The dominant finding is that it is virtually impossible to distinguish between trained and untrained people on delayed measures of their personal financial practices (Willis 2009). Finally, school-wide discipline programs that emphasize developing agency through either social-emotional learning or behavior supports and social skill training have quite modest effect sizes—around .21—on preventing aggressive and disruptive behavior (Wilson and Lipsey 2007).

When researchers attempt to identify features of prevention education programs that seem to contribute to success, the evidence indicates that comprehensive, focused, interactive, and long-term interventions that teach specific practices have the greatest effects on attitudes and actions (Cuijpers 2002). In contrast, dispensing information, which is a common feature of many programs, is the least effective approach. These findings suggest that fostering agency requires reasonably strenuous efforts, that is, explicit, action-focused, resolute, and far-reaching environmental education programs are the most likely to promote agency and lead to personal action.

The relatively limited consequences of prevention interventions on personal action are probably rooted in a number of factors. Certainly the attitudes and practices embedded in a sociocultural context are powerful determinants of an individual’s interpretations and actions in situations. In this sense, environmental education is often working against the grain of local traditions and attitudes. It is also important to note that the focus on personal agency masks the often more powerful influences of corporations and political systems in generating consequences. In financial education, for example, emphasizing personal action is a convenient way to turn attention away from the need to regulate such things as predatory loan practices employed by financial institutions for their own profit. Similarly, an individualistic focus in environmental education ignores the potent effects of corporate and governmental policy on the environment.
A second factor, however, would seem to be operating within the context of prevention. To act on one’s own behalf or on the behalf of others requires that an individual perceives a need to act. In many of the areas typically targeted by prevention education, individuals have what Neil Weinstein (1989) called “unrealistic optimism,” that is, they perceive that their own risk of becoming addicted to drugs or alcohol, of committing suicide, of being seriously injured in an accident, of being obese, of developing diabetes or cancer, and so forth, is less than that of other people like them. This optimism bias, which is consistently found across diverse populations, means that individuals do not engage in actions that might reduce their actual risks, including wearing seatbelts, quitting smoking, eating a better diet, and exercise. In other words, they see limited risk and thus little need for agency in their own best interests. It is not surprising that most of the social change in such areas as smoking and seat belt use came about because of legislation rather than prevention education programs.

These findings would seem to be particularly salient for environmental education. If people are likely to underestimate personal risk, they are probably even more likely to underestimate environmental consequences and risks, which are often perceived as quite remote from daily life.

This analysis of prevention education and the optimism bias suggests that student agency is not easily accomplished and we should not expect large consequences from relatively small interventions.

Agency as a pedagogical element

A second perspective on agency can be gained by examining the contemporary emphasis on “ambitious teaching” in both science and mathematics education (Marx and Harris 2006). In contrast to traditional teacher centered delivery of specific lessons and units of content, ambitious teaching centers on the big ideas of a discipline and involves the design and launch of authentic problem tasks or spaces in which students engage in critical problem identification and structuring and generate their own explanations of why procedures or findings make sense. One especially salient version of ambitious teaching emphasizes teaching science or mathematics for social justice (Turner, Varley Gutiérrez, Simic-Muller and Díez-Palomar 2009). From this perspective, content becomes a tool within a sociocultural milieu to understand and address social and political issues. In ambitious teaching contexts, students exercise agency in their own learning, achieve authentic mastery of the content as a tool for understanding and action, and develop agency to act autonomously.

Despite the potential of this pedagogical framework as a venue for nurturing student agency, it is rarely seen in practice and is often difficult to enact in conventional classroom contexts (Lampert, Boerst and Graziani 2011). A major part of this difficulty arises from the inherently complex activity systems that exist in classrooms as sociocultural artifacts (Doyle 2006). Classroom groups come together for long periods of time—several weeks or months at a time—to accomplish a wide range of academic, social, and personal goals. To achieve a stable, functioning classroom system, a teacher must organize the several dimensions of classroom life and recruit, invite, persuade, or convince the students to join forces with her or him in the service of common goals. Such settings develop an organization and procedural history and norms of acceptable actions and levels for accountability. The key elements of this process—order, lesson, curriculum task, student, and teacher—are culturally and historically situated. What classroom order, a five-paragraph
theme, seatwork, a sixth-grade student, a beginning teacher, all mean is mediated by history and culture both at societal and local levels. A science experiment, for example, has been seen before by students and teachers, has a status within various pedagogical ideologies, is associated with teachers’ practical knowledge about utility and consequences, has a history within a particular classroom and within a student cohort, and so forth. Such meanings, albeit multifaceted and often indeterminate, play a central role in constituting and stabilizing order at a particular moment in a particular place. Importantly, a teacher’s practical reasoning exists in and grows out of engaging in this problem-directed action in particular classroom settings. Thus, what a teacher accomplishes in a classroom is a culmination of her or his ability to understand the probabilities of classroom events and anticipate where action is likely to lead.

Ambitious teaching relies on novel pedagogical forms. Understandably, then, teachers face special challenges in enacting such forms in time and space. In addition, ambitious teaching reconfigures the task demands students face as they navigate classroom life (Doyle 1983). Typically students are asked to accomplish work that involves searching and matching information in texts to questions, recognizing or reproducing information they have already seen, or applying a reliable formula to produce answers. Such work is familiar and routine and accomplished in a context of plentiful resources and prompts. Ambitious teaching calls upon students to discern the structure of novel and authentic problems and invent their own solutions and explanations. Such demands represent a substantial increase in both the ambiguity of the problem space and, if there is accountability, an increased risk of missing the mark.

A variety of studies have shown that such novel academic tasks, that is, tasks in which students must produce work through their own understanding and invention, are unstable (Doyle 1988). Launching such tasks can be challenging because their description must necessarily be incomplete to leave room for student invention. In such circumstances, students typically demand that teachers be more specific or reduce accountability standards, and they can even resist engaging in the work at all, which can break lesson momentum and disrupt order in the class. Moreover, students’ work products are difficult to judge because the criteria are imprecise. Faced with these demands, teachers frequently reconfigure tasks to change the ambiguity and risk students face and thus modify the nature of the work. When this happens, authentic work can become routinized and formulaic.

This analysis suggests that creating classroom conditions that rely upon and activate student agency can be difficult to orchestrate and have a high probability of failure except when enacted by very experienced and skilled teachers.

Conclusion

This meditation on the many faces of agency suggests that it is an intrinsically complex pedagogical idea and, as an educative outcome, is perhaps more elusive and problematic than we usually envision. In most instances, the term seems to be used as a symbol to capture a particular ideological vision rather than as an empirical phenomenon that operates in real-world contexts. This is not to say that agency is not an extremely important construct. It is rather a call for much more rigorous and analytical attention to the meaning of the term and how it can and does functions in educative environments.
References


Walter Doyle is professor in the Department of Teaching, Learning, and Sociocultural Studies in the College of Education at The University of Arizona. His research focuses on classroom processes, curriculum theory, and practicality. Currently he is focused on bridging tools and designs for making pedagogical models and innovations practical.
Making the implicit explicit: environmental teacher as a “reflective practitioner”

Cláudia Faria

Abstract This forum article consists on a commentary on the article by Alandeom W. Oliveira, Patterson Rogers, Cassie F. Quigley, Denis Samburskiy, Kimberly Barss and Seema Rivera. The authors emphasized the need for environmental teachers to expand the focus of their instructional efforts beyond rational argumentation and reasoning, taking into account the complex emotional aspects of the human relationship with nature. In this commentary, I attempt to extend the conversation regarding these issues to the need for teachers to be aware about their own environmental beliefs, which could be guiding their teaching. I close with a consideration for the need for environmental teachers to be reflective practitioners, using reflection upon the ends of education, their environmental values and ideas and the moral and ethical aspects of teaching, for challenging students’ beliefs and empowering them to make informed environmental decisions, contributing thereby to the building of more just and environmental sustained societies.

Keywords Implicit discourse · Environmental agency · Reflective teachers

In their manuscript, Environmental Agency Read Alouds, Alandeom Oliveira and colleagues discussed some aspects related with the patterns of environmental agential attribution from elementary teachers and students, based on the analysis of three environmental read-aloud case studies. The authors highlighted the need to raise educators’ awareness about the necessity of expanding the focus of their instructional efforts beyond rational argumentation and reasoning, and their work reveals the potentiality of this strategy,
environmental read-alouds, in helping teachers to cope with students’ multiple and often conflicting motivations and beliefs that often underlie environmental issues.

In this commentary I would like to highlight the other side of the question, which is the need for teachers themselves to be conscious about the different patterns of agential attribution implicitly present in their own discourse, and the need to balance them, when implementing this type of pedagogical strategy, or even others, when discussing any environmental issue with students.

Environmental issues are some of the most pressing social problems of our time. From pollution, global climate change, and depletion of natural resources, to poverty, social exclusion and public health, environmental problems threaten the individuals, communities, and all living organisms on the planet. For addressing these issues, it is important to understand what motivates people to act in an effort to preserve the natural environment.

According to Coral Bruni, Randie Chance and Wesley Schultz (2012), children’s environmental concerns for the consequences of human impact on the environment are organized around three factors: self, other people, and the biosphere. This model states that a person’s environmental attitude is rooted in its basic values system and is relative to the importance that a person places on each of these factors (Schultz 2001). Even in actual conservation management decision making, scientifically objective criteria are compromised by the multiple demands placed on land, and conservation management programmes are increasingly expected to fulfil cultural, educational and amenity roles (Boza 1993). Indeed, values and scientific ideas are closely connected in the human mind. Concerning environmental education, nowadays it is recognized that although students use both scientific concepts and values in deciding about conservation issues, they appear to give more weight to values (Grace and Ratcliffe 2002). Besides, although the engagement with school is a multidimensional construct, encompassing behavioural, cognitive and affective dimensions, which interact in a complex and dynamic way (Fredericks, Blumenfeld and Paris 2004), according to Louis Iozzi (1989), the affective domain is actually a key entry point in learning and determines whether or not a student finds environmental content relevant enough and worth learning.

As Oliveira and colleagues argued in their work, the idea that personal and social values play a central role in shaping the human relationship with nature illuminates the need for environmental teachers to expand the focus of their instructional efforts beyond rational argumentation and reasoning, taking into account the complex emotional aspects of this relationship. Though the problem also raised by this argument relates with the environmental beliefs of teachers themselves: what about teachers’ values that could implicitly be transmitted in teachers’ discourse and discussion options during their teaching?

Teachers’ environmental beliefs could be more important in guiding their teaching about controversial environmental issues than has previously been recognized (Cotton 2006). Indeed, teachers send powerful messages to students through what they do in the classroom, and the kinds of discussions they will and will not engage in, and even through the language they use (Arreguin-Anderson and Kennedy 2013). Mario Teisl and colleagues (2010) in a study with students of two environmental courses taught by five different instructors, found that although student environmental attitudes changed, these changes differed substantially depending upon who taught the course. Conversely, they found few differences in attitudinal changes when the instructor was the same, even when the course content differed. The authors concluded stressing the possibility of students being influenced by the environmental attitudes of the instructor or by their educational beliefs.

According to Ken Zeichner (2008), the most important point to think about teaching is that it can never be neutral. Teachers have a curriculum full of values and beliefs, and every choice they make in the classroom demonstrates an underlying value (Totterdell
For this reason, teachers not only need to have pedagogical and academic knowledge in order to promote greater understanding (Zeichner 2008), but, more importantly, they must also have an awareness of their own values-based positions, regarding teaching and regarding the content they teach.

In science education in general, and in environmental education in particular, it is intended that teachers challenge their students’ beliefs and points of view by offering different perspectives and allowing students to consider their options and to make informed decisions (Sims 2004). Indeed, in environmental education, students are expected to, in an autonomous way, critically appraise issues related to the environment, and to develop awareness, knowledge, skills, and commitment to result in informed decisions, responsible choices concerning lifestyle and behaviours, and even constructive actions concerning the environment (Arreguín-Anderson and Kennedy 2013).

These goals demand advanced critical thinking skills and strategies from teachers, to move students forward in their thinking with open-mindedness. For this, teachers need not only to know how their work affects students’ attitudes, but also to make explicit their own values in what and how they teach (Mergler 2008). According to Amanda Mergler (2008), “clarity about one’s stated values, and teaching choices made in response to one’s actual values, is imperative if teachers are to reflect meaningfully on what they do in the classroom” (p. 2). Striving to make this somewhat ‘hidden curriculum’ transparent, making explicit the values that are, in many cases, embedded in them, will help teachers to reflect about the ways in which they shape the values of their students (Mergler 2008).

The question that arises is what teachers need to assist them in this demanding task? Reflection is currently a key concept in teacher education (Korthagen and Vasalos 2005). Connecting teacher reflection to the struggle for social justice and environmental concern, and the inclusion of reflection upon the ends of education and the moral and ethical aspects of teaching in teachers’ education, means that in addition to making sure that teachers have the content and pedagogical background needed to teach in a way that promotes student understanding, we need to ensure that teachers make decisions in their work with greater awareness of the potential consequences of the different choices made, and that they know how to make decisions on a daily basis that do not unnecessarily limit the life chances of their students (Zeichner 2008).

The kind of education needed today requires teachers to be high-level knowledge workers who constantly advance their own professional knowledge as well as that of their profession, being capable of reflecting on their practices in order to learn from their experience (Schleicher 2012). This does not mean that individual teachers must think only by themselves about their work. The work of a reflective teacher can not be a solitary one (Zeichner 2008). The challenge and support gained through social interaction is important in helping anyone in clarifying what he/she believes and in gaining the courage to pursue her/his beliefs. Probably, teachers’ education should be focused not only on the use of reflection, but also on the use of reflection as a social practice that takes place within communities of teachers who support and sustain each other’s growth (McLaughlin and Talbert 2006).

References


Cláudia Faria is Researcher at the Institute of Education of the University of Lisbon. She has a Ph.D. in Biology. She has been involved in several research projects in Biology and Ecology and in science teacher training. Presently she participates in an international project focused on how to support teachers in adopting inquiry based science education (IBSE) and in developing appropriate strategies for the assessment of IBSE skills and competences. She also coordinates a national project centred on the promotion of different kinds of literacy through IBSE, in formal and non-formal contexts (like science museums).
The discourse of design-based science classroom activities

Flávio S. Azevedo · Peggy L. Martalock · Tugba Keser

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Abstract This paper is an initial contribution to a general theory in which science classroom activity types and epistemological discourse practices are systematically linked. The idea is that activities and discourse are reflexively related, so that different types of science classroom activities (e.g., scientific argumentation, modeling, and design) recruit characteristically distinct forms of participants’ (students and teacher) discourse. Such a general theory would eventually map out the full spectrum of discourse practices (and their patterns of manifestation) across various kinds of science classroom activities, and reveal new relationships between forms of both discourse and activities. Because this defines a complex and long-term project, here our aim is simply to delineate this larger theoretical program and to illustrate it with a detailed case study—namely, that of mapping out and characterizing the discourse practices of design-based science classroom activities. To do so, we draw on data from an activity that is prototypically design-based—i.e., one in which students iteratively design and refine an artifact (in this case, pictorial representations of moving objects)—and examine the structure and dynamics of the whole-class discourse practices that emerge around these representational forms. We then compare and contrast these discourse practices to those of an activity that is prototypical of scientific argumentation (taken from the literature)—i.e., one in which students argue between competing theories and explanations of a phenomenon—and begin to illustrate the kinds of insights our theoretical program might afford.

Keywords Activity types · Discourse · Design-based activities · Argumentation · Science education
The discourse of participants in science classrooms has been the subject of much recent research (Kelly 2007). Motivating these pursuits is the observation that professional science is founded, to a large extent, on a variety of discourse practices through which scientists advance new theories or challenge existing ones, defend positions and attempt to persuade others, collaborate with peers and recruit resources, among others (Lynch 1993). To engage students in such discourse practices, therefore, is to provide them with opportunities to participate in core aspects of scientific disciplines, and indeed to examine the deep assumptions and foundations of these disciplines (Bricker and Bell 2008).

In this paper, we seek to jumpstart a sizeable theoretical program that foregrounds some yet-unexplored facets of the relationship between science classroom activities and participants’ discourse. Specifically, our goal is to begin outlining a general theory of the intersection between science classroom activity types and discourse practices and to illustrate the program’s development with the analysis of the discourse of a specific science classroom activity. To elaborate, the idea is that different types of science classroom activities (e.g., scientific argumentation, modeling, and design-based ones) have distinct underlying nature and therefore they recruit characteristically distinct forms of participants’ discourse, students and teacher alike. For instance, the whole-class discussions of an activity in which students model the growth of plants (Lehrer and Schauble 2005) differs, at a foundational level, from that of an activity in which students argue between competing scientific theories (e.g., Osborne, Erduran and Simon 2004). In fact, because activity and discourse are reflexively related (Goodwin 2000), the nature of one must directly impinge on the nature of the other (Gee 1991). Our envisioned theoretical program would eventually map out the full spectrum of epistemological discourse practices of various science classroom activity types, as well as their many variations. Pragmatically, in the long haul such a map would provide teachers with a textured account of the discourse practices characteristic of various science classroom activities and aid them in selecting, combining, tailoring, and matching learning activities to the discursive needs and abilities of their pupils.

Steps to the theoretical program

A general theory of the intersection between science classroom activity types and discourse practices may be pursued in many different ways. Here, our approach will be to (1) minimally (but clearly and unambiguously) outline a process through which the theory might be developed and (2) to substantiate it with the empirical analysis of the discourse practices of a design-based science classroom activity. By doing so, we hope to establish the feasibility and conceptual worth of the program and to attract others to contribute to its long-term development.

Our minimal specification for the theoretical program involves essentially two steps. First, we consult the literature for various science classroom activity types—for example, design-based activities (Kolodner, Crismond, Fasse, Gray, Holbrook and Puntambekar 2003), scientific inquiry (White and Frederiksen 1998), modeling (Lehrer and Schauble 2005), and scientific argumentation (Newton, Driver and Osborne 1999), to cite some common ones. For each such type of science classroom activity, we then single out for analysis an actual classroom implementation that is a prototypical instance (Lakoff 1987) of the larger activity category to which it belongs. A prototypical instance of any science classroom activity type embodies, in its most schematic form, the defining properties of a larger set of similar activities. Prototypical activity instances may be found in the literature or through empirical research, as we will see. But the main point is that, by starting with
prototypical instances, we seek to obtain quick analytical gains by capturing an activity type’s core defining features while also avoiding the complications that arise from studying more “complex” activity sequences (say, as when students must negotiate and set up/run empirical experiments and then argue about their findings). Documenting and explaining the discourse practices of each prototypical activity instance can then serve as the basis upon which more elaborate and refined characterizations of discourse qua activity can be built.

To illustrate prototypical activity instances with a concrete example—one to which we will return throughout the paper—consider Katherine McNeill and Diane Pimentel’s (2009) investigation of structural and dynamic characteristics of scientific argumentation discourse, as observed in three distinct, 10th grade urban classrooms implementing the same lesson on global climate change. At the beginning of the lesson, students in each class watched two short videos (each about 5 min long), the first of which presented evidence supporting the theory that the earth is warming up (as a result of human activity), whereas the second advanced the opposite stance. For about 10–15 min, students then participated in a whole-class discussion in which they argued for either of the two positions, much as scientists do when they defend theories and/or attempt to displace competing viewpoints. Teachers in each class intervened in different ways and to different degrees, but none of these interventions altered the basic arguing give-and-take structure of the activity (as it happens, say, when argumentation is embedded within the larger task of explaining some phenomenon that students must observe, test and/or explain, as implemented in Sampson and Clark 2008).

As we will see, McNeill and Pimentel’s analysis is very insightful and it reveals important relationships between students’ and teachers’ discourse patterns, particularly as related to the quality and frequency of students’ scientific argumentative discourse. For the moment, however, the main point to observe is that McNeill and Pimentel’s classroom activity can be taken as a prototypical instance of scientific argumentation activity structures. Scientific argumentation can be defined as “the coordination of evidence and theory to support or refute an explanatory conclusion, model, or prediction” (Osborne et al. 2004, p. 995), and its classroom incarnation is often structured such that students must continuously address each other’s positions/theory (Andriessen 2006), in the process articulating claims, evidence (data), warrants and backings that constitute their own theoretical position (Erduran and Jiménez-Aleixandre 2007). Central to the argumentation activity is the “generation of differences” (Osborne et al. 2004, p. 1001)—that is, the presentation of two or more competing theoretical interpretations of a phenomenon, such as opposing theories of global warming anchoring McNeill and Pimentel’s study—which provide both the initial material for students’ arguments and the overall framework for participation in the activity (Kuhn 2010). This pattern of student-generated claims/theory turn-taking that responds to competing positions, aided by the teacher’s various guiding moves, is thus the most basic and defining feature of scientific argumentation activities (Bricker and Bell 2008), and McNeill and Pimentel’s global climate change unit can be taken as a prototypical instantiation of these.

An initial development of the theory: analyzing the discourse of design-based activities

To begin illustrating our theoretical program, the substantive task we take up here is the analysis of the discourse practices of an activity that is a prototypical instance of design-based science classroom activities. At the core, design activities are concerned with the creation of an artifact or process that solves a given problem (Goel and Pirolli 1992). Crucially, the activity of design proceeds in cycles of artifact creation, assessment (i.e., a
test of the goodness of fit of a solution), and redesign, so that the resulting product is refined in an iterative manner. There are certainly complex variations and add-ons to the basic design process, perhaps best illustrated by the multi-stage, non-linear processes commonly taught in engineering design courses (Katehi, Pearson and Feder 2009). But fundamentally, these also retain the defining, characteristic cycle of design and its focus on artifact refinement—a process that has been synthesized by Wendy Newstetter’s (2000) scheme ‘defining → creating → assessing → redesigning’ (where defining can be a given).

In the classroom data we will analyze, the artifacts students designed and re-designed were pictorial representations of moving objects (e.g., graphs or conventional drawings a car traveling at varying speeds or a dropped ball of clay) and these representations were to be used in different functional contexts (Please refer to Fig. 1 for examples, to be fully explained later). We termed our activity Inventing Graphing (IG) because its intent was to provide a framework for students to design and refine representational forms that progressively approximated Cartesian graphing (diSessa, Hammer, Sherin and Kolpakowsky 1991).

Like other instances of design-based science classroom lessons (e.g., Fortus, Dershimer, Krajcik, Marx and Mamlok-Naaman 2004), in representational design activities such as IG students create a baseline artifact and iteratively refine their “inventions” based on design trade-offs raised during whole class discussions (or some alternative form of design assessment, such as the empirical testing of solutions; Kolodner et al. 2003). This process is repeated several times, perhaps with some variations resulting from teachers’ differing pedagogical styles, but at the core it retains the create-and-refine cycle characteristic of design tasks. As a first approximation, then, our representational design activity may be taken as a prototypical instance of design-based science learning activities and its analysis will serve as the focal point for the theoretical program we wish to advance.

Fig. 1 a The “Sonar” representation of the desert motion uses the vertical length of lines to show speed (Benson, scanned from original); b the “Eifel” representation, in which the thickness of lines show speed (Benson, scanned from original); c Larry describes his solution to the desert motion—a standard Cartesian graph (UTDP’97); d Charles’s hybrid representation of the desert motion, blending elements of both graphs and drawings (UTDP’97)
The structure of the paper

The paper is structured as follows. In the next section we briefly review the literature bearing on our work. In the immediately subsequent section, we further elaborate on that literature by weaving a theoretical framework suitable for capturing and describing the intersection of discourse practices and classroom activity. We then consider, in some detail, the research context and methods we used in our study, and move on to present an extended analysis of the discourse practices of IG activities. This constitutes the bulk of the paper and it addresses the following questions: What discourse practices of science are characteristic of a prototypically design-based science learning activity? What are the central features of each such discourse practice (i.e., what is their structure and dynamics)? What patterns do these discourse practices fall into, and how do these patterns emerge from the reciprocal interactions between classroom participants? As we address these questions, we systematically compare and contrast the discourse of IG to that of McNeill and Pimentel’s (2009) scientific argumentation activity. Doing so allows us to simultaneously illustrate our larger theoretical program.

Design and discourse in the classroom: a brief review

The extensive uses of design in professional STEM practice have long been documented (Knorr-Cetina 1999). Indeed, design is regarded as the central problem solving method of the engineering professions (Katehi, Pearson and Feder 2009) and design-centered instruction often organizes whole curricula in engineering education (e.g., Brophy, Klein, Portsmore and Rogers 2008). Closer to our concerns with science instruction, the use of design-based activities has seen some success in science classrooms ranging from middle to high school. In Massachusetts, for example, the engineering design process (EDP) has been a part of the state frameworks since 2000 and about one quarter of the science curriculum in the state uses some version of EDP-based activity (Hynes 2012).

As an activity type, design has many properties that make it an excellent form of pedagogy for the science classroom (diSessa and Sherin 2000). As Mitchell Resnick (1996) noted, design activities: (1) are about trade-offs, rather than correct/incorrect answers, and therefore they foster a pluralistic epistemology centered on the use of multiple strategies and solutions; (2) engage students as active participants and give them a greater sense of control over the learning process; (3) are often interdisciplinary, which may help students build bridges between disciplines; and (4) support reflection and discussion, given the permanence of the designed artifacts.

Backed by these ideas, researchers have explored design as a medium for the teaching and learning of various science subjects and disciplines. Janet Kolodner and collaborators’ Learning by Design (LBD) project, for example, has developed curricula in which students design, build and test small vehicles to learn about Newtonian mechanics or devise ways to manage the erosion of barrier islands to learn about water currents (Kolodner et al. 2003). In all cases, the design and refinement of one or more artifacts ground investigation of scientific concepts, providing a coherent structure for students’ activities and growing understanding of both science and design.

A similar approach appears in David Fortus and collaborators’ Design-Based Science (DBS) project, with curricula focused on long-term projects such as designing a house to withstand extreme weather conditions, developing a battery that is environment friendly, and conceiving a cell phone that minimizes potential radiation and sound hazards (Fortus...
et al. 2004). DBS shares much with LBD in terms of structuring and scaffolding of students’ pursuits, but differs in that any single DBS unit targets multiple simultaneous conceptual learning goals, whereas an LBD unit targets a narrower set of learning goals, which are usually presented in increasing levels of complexity.

Both LBD and DBS units may implement design cycles that are more or less complex and non-linear, depending on a teacher’s goals and style. Usually, in both cases the design process takes on a large number of phases, but whether or not design phases must be sequentially traversed is at the teacher’s discretion (Hynes 2012). For our purposes here, the most critical issues regard what patterns of activity (and associated discourse practices) might be elicited as students work through a canonical cycle of design.

At the other end of our concerns, the study of science classroom discourse has seen considerable growth in recent decades. According to Edwards (2005), the general term, discourse analysis, covers a broad variety of studies of language use, which have been carried out from such perspectives as diverse as the ethnography of communication, conversation analysis (CA), interactional sociolinguistics, critical discourse analysis, and systemic functional linguistics. He points out that, given the various perspectives brought to the issue, discourse analysis “covers a range of somewhat related but mostly contrasting kinds of work” (p. 62). Thus, at times discourse analysis is framed as a general methodology, but in different contexts it is advanced as a tool for ideological critique and the consequent exposure of oppressive relations in the school (Fairclough 1992).

Often, methods of analysis are sharply defined within distinct types of discourse analysis. For example, applied linguists may focus on textual materials rather than spoken interactions, perhaps searching for content and grammatical structures that expose processes of institutional power (Davis and Elder 2004). Others rely on CA and its use of transcribed recordings of “ordinary” talk that are scrutinized for how individual’s turns-at-talk perform specific social actions (Sacks, Schegloff and Jefferson 1974). Still other kinds of discourse analysis use no particular procedure of detailed analysis, but instead search for patterns of language use associated with topics ranging from the content and form of students’ utterances to issues of power and social structure in the classroom.

The work of Jay Lemke (1990) perhaps best illustrates this eclectic focus on discourse practices in science classrooms. Lemke considered linguistic phenomena at various levels of analysis, from the fine-grained thematic structure of an utterance (e.g., as in CA), to patterns in exchanges between parties (such as the Initiation-Response-Evaluation sequence prevalent in traditional classrooms), to even larger patterns in participants’ joint construction of the “lived curriculum” (say, as in teachers’ systematic modifying and/or re-contextualizing students’ contributions). In doing so, he touched on issues ranging from the content of students’ learning to issues of power and identity development.

Much research has followed since Lemke’s early contributions (see Kelly 2007 for a synthetic review) and the focus and grain-size of analyses have varied across distinct communities of science education research. Regarding the interactions between teacher and students in the science classroom, for example, the concept of revoicing adds to Lemke’s account of how particular discursive “strategies” are often used by the science teacher for various functions, including reformulating, clarifying, and rebroadcasting students’ contributions (O’Connor and Michaels 1996). Revoicing also crucially affords the teacher the means to position students’ answers regarding issues at stake, and thus to create the alignments and discrepancies among positions that fuel rich conceptual argumentation (O’Connor and Michaels 1996). Whether or not such rich discussions take hold, however, depends much on how the teacher frames ongoing activities, with consequences for the kinds of discursive contributions students might make and the discourse patterns.
that emerge in any given activity (Michaels, O’Connor and Resnick 2008). We will take up these issues in the analysis section.

Focusing on more open-ended, long-term classroom activities, on the other hand, Randi Engle and Faith Conant (2002) showed how teacher’s discursive moves may serve functions such as preventing premature closing of discussions, problematizing the content of lessons, and holding students accountable to norms of argumentation. Reflexively, teachers’ moves were associated with what the researchers termed students’ productive disciplinary engagement—often assessed through reference to students’ discursive moves such as demanding evidence for arguments, questioning information sources and credibility, increased articulation of evidence and justification, etc. Key to our goals here, these researchers also showed that participants’ contributions were tied to the disciplinary features of the activity and the classroom community, in effect illustrating some of the context-dependency features of classroom discourse that we will consider throughout the paper.

In a related manner, more recently a strong focus has developed around investigating the discourse practices of science classrooms in relation to some key epistemological practices of science. Chief among these have been studies of students’ explanations (Berland and Reiser 2009) and argumentation (e.g., Newton, Driver and Osborne 1999) in several scientific disciplines. Indeed, the idea of teaching the whole of science as argumentation has gained some traction (Kuhn 2010), which explains the high number of studies of science classroom argumentative discourse in the literature (Cavagnetto 2010). We will develop some of the major themes of that literature in the upcoming sections.

**Theoretical framework**

Because we investigate the intersection between epistemological discourse practices and science classroom activity types, our theoretical framework must be flexible enough to capture central conceptual axes of both classroom discourse and the socio-culturally patterned organization of activities. In this regard, no single theoretical tradition is likely to provide adequate conceptual and theoretical coverage for our needs. We thus draw on a few distinct, but strongly overlapping theoretical traditions, specifically socio-cultural (Saxe 1991) and situative frames of learning (Greeno 2006), CA (Sacks, Schegloff and Jefferson 1974), and interaction analysis (Jordan and Henderson 1995).

Adding a further layer of complexity, our larger theoretical project requires that we place our findings on the discourse of design-based activities in relationship to the discourse practices of other types of science classroom activities. Borrowing strategically from related research is thus a must if the requisite activity cross-category comparisons are to be readily made. It follows that our theoretical framework must somehow be responsive to the work of others, both conceptually and methodologically.

In addressing these simultaneous demands, we note that there is much common ground between the theoretical traditions from which we draw and the bulk of contemporary research on science classroom discourse. To begin, like many others in the field we take a broadly socio-cultural lens on learning and knowing (Lave and Wenger 1991) and the way these emerge from participants’ interactions and discursive contributions to ongoing activities. Even those researchers who do not explicitly subscribe to any methodology of systematic discourse analysis frame their arguments on some form of “interactionist” perspective (e.g., Engle and Conant 2002)—i.e., one in which patterns in classroom talk and participation are seen as co-constructed by teacher and students, within norms and
values of practice that are constantly negotiated by participants. A case in point is the work of McNeill and Pimentel (2009)—previously reviewed and the central contrasting case we use here—with its focus on talk and turn-taking among participants, the mutual addressing of different positions, and how these are “strung up” into patterns of argumentation that were meaningful to participants (See Cavagnetto (2010) for a thorough review of research that takes the same stance).

A broadly socio-cultural frame on participation and discourse also emphasizes the way power may be differentially distributed among participants in a setting (Lave and Wenger 1991). In the case of schools, in particular, we take it that teachers have significant discretion directing or otherwise influencing classroom interactions (Gee 2004). Or, as interaction analysts would put it, in classroom settings teachers are officially in charge of turn allocation (Jordan and Henderson 1995). Accordingly, our analysis is centrally concerned with the contributions of all classroom participants, with particular attention to how teacher’s interventions might centrally shape the structure and overall dynamics of whole-classroom discourse (e.g., Engle and Conant (2002), reviewed above). By the same token, we must explain any instances in which a teacher’s interventions do not alter the flow of discourse among students, both locally and in the long-term.

Shifting to discourse, a common assumption (implicitly or explicitly) has been that meaning is made in the way participants’ turns-at-talk address each other and continuously set the stage for the exchange of ideas (Walsh 2011). In McNeill and Pimentel (2009), for example, students’ and teacher’s utterances were studied in their sequential organization, the way they responded to and shaped each other, and how these added up to patterns of scientific argumentation that varied with teachers’ distinct pedagogical moves. This kind of analysis, of course, derives directly from CA (Sacks 1972) and the powerful conceptual and analytical tools associated with the methodology.

Conversation analysis has its origins in the work of sociologist Harvey Sacks and collaborators Emanuel Schegloff and Gail Jefferson (Goodwin and Heritage 1990). Originally devised as a methodology for the systematic study of casual, everyday interactions such as phone conversations or hallway exchanges, CA has found fertile grounds in studies of discursive phenomena in institutionalized settings such as science labs (Hsu, Roth and Mazumder 2009), courts, museums, doctor’s offices, classrooms, and many others (Goodwin and Goodwin 1992). As a method for the study of talk-in-interaction in the classroom, CA directs our gaze to mechanisms of turn taking between participants (i.e., among students and between teacher and students), the methodic organization of turn taking, the systematic resources that participants deploy during conversations, and the meanings that circulate during these processes (Hutchby and Wooffitt 2008). From this perspective, “meaning lies not with the speaker nor the addressee nor the utterance alone… but rather with the interactional past, current and projected next moment” (Schegloff, Ochs and Thompson 1996, pp. 40).

As an illustration of CA-inspired work, let us resort again to Engle and Conant’s (2002) extensive analysis of 5th graders’ productive disciplinary engagement in a long-term unit in biology, as seen in students’ discursive contributions. In many of the recurrent episodes of engaged participation, students’ discourse centered on a controversy regarding the classification of orcas as dolphins or whales. While questions of taxonomy were quite parallel to the goals of the lesson, students became passionate about the issue and spontaneously returned to it several times across the unit. By following the moment-to-moment exchanges of students’ turns-at-talk to spot how the controversy erupted and was taken up downstream, the researchers show how specific meanings and concepts appear in students’ argumentative discourse. Similarly, by tracing the long-term history of the orca argument,
they show how patterns of discussion around the issue fluctuated over time (e.g., showing students’ growing understanding of the need to back up their claims) and built on the prior discursive contributions of the group.

Here, too, CA is used both as a framing assumption and as a method of analysis. As a framing assumption, our investigation is concerned not only with orderly turn-taking between participants but also with what participants take it that they are actually doing in their activities—i.e., the shared objective of their work, which is essential part of the activities’ meaning. It is by looking at the content of this emergent, shared collective focus of conversations that we identify the epistemological discourse practices at the core of the activities that we analyze. For example, in the case of activities that are structured around the arguing of competing theories (e.g., McNeill and Pimentel 2009), participants most typically orient towards the need to decide what theory best accounts for the available evidence (e.g., Osborne et al. 2004). In design-based activities such as IG, in contrast, patterns of discourse will most likely settle on the trade-offs of various representations/design solutions. The point is that exchanges between participants will converge on specific requirements of specific classroom activities, and these are informative of what is epistemologically significant in participants’ talk.

As a method of discourse analysis, CA provides just the right grain of analysis—turns at talk and clusters thereof—for our purposes of uncovering the context-bound nature of students’ contributions (perhaps made of multiple utterances) and what these do in terms of eliciting social action from others (e.g., comments and arguments, in a continuous sequence of exchanges). Furthermore, providing alignment for our cross-comparison analysis, turns-at-talk has been a common unit of analysis in studies of argumentative discourse, as reviewed previously (in contrast to, say, those working from a critical discourse analysis or systemic functional linguistics perspective, in which a very different grain size of analysis is standard).

We add to traditional studies in the CA tradition by noting that different activity types may recruit a variety of semiotic resources beyond talk (e.g., Goodwin 2000), and accounting for how these resources are assembled in communicative action is a must for our project. Originally conceived as a method of analysis of spoken phenomena, CA has been extended to incorporate how gesture and inscriptions (e.g., graphs, tables, and diagrams) that are ubiquitous in the discourse of certain settings are folded into/assembled in discursive action (Goodwin and Goodwin 1998). In particular, the professional practices of techno-scientists are heavily mediated by tools and material/representational infrastructures (e.g., Lynch and Woolgar 1988, and these are part and parcel of how professionals in these disciplines talk about and carry out their work, articulate arguments, stabilize meanings (Hall 1996), and so on. As an example, Elinor Ochs, Patrick Gonzales and Sally Jacoby (1994) provides an account of how a group of physicists “inhabit” and travel through Cartesian graph spaces through the coordinated use of talk and gesture over a shared graphical space.

In science classrooms, this should be not different (Greeno and Hall 1997). When translated to the specific context of our IG activities—in which the goal is to craft a widely understood semiotic form for showing the movement of an object—we thus expect students to talk with and about their representations (Hall and Stevens 1995), and therefore emergent discourse practices and structures must be tied in some way to the discursive work done by these representational forms (Goodwin 2000). Following an interaction analytic perspective, whenever appropriate we follow not only turns-at-talk, but also turns with bodies and turns with artifacts (Goodwin and Goodwin 1998). As we will see, the material aspects of different kinds of science classroom activities will be more or less
salient in participants’ discourse across activity categories (e.g., design-based and scientific argumentation), and we expect our larger theoretical program to help shed light on the issue.

In addition, because our broader theoretical goal is to explicate how epistemological discourse practices vary across classroom activity types, by definition we view discourse as necessarily domain-/discipline-specific (Bricker and Bell 2008), rather than domain-general (Kuhn 2010). Classroom communities develop largely around the disciplinary practices the community enacts and values (Greeno 2006), and these disciplinary norms and standards must somehow appear in participants’ talk (Gee 2004). Thus, when a participant’s discursive move—say, a teacher’s questioning or a student’s request for clarification—is seen to shift the pattern of classroom discourse and activity, we seek to explain this shift in terms of how such questions directly impinge on participants engaging the very process and products (i.e., the specific substantive content) of the design activity (e.g., Engle and Conant 2002).

A commitment to the discipline-specific nature of science classroom discourse also suggests that we keep an open stance with regard to what epistemic discourse practices we might find in our representational design activities (e.g., Bricker and Bell 2008). For example, a prototypical instance of scientific argumentation activities (such as McNeill and Pimentel’s) will be plausibly dominated by a specific form of discourse—namely, the arguing give-and-take pattern of discourse that defines the multi-party dialogue of theory building. In contrast, the discourse practices of a design-based lesson are perhaps multiple, given that the activity is about conceiving, building, and talking about an artifact (material or conceptual). Finding what such practices are, of course, is the central goal of the paper.

Beyond these, because we often borrow from McNeill and Pimentel’s (2009) analysis of a (prototypical) scientific argumentation activity to frame our own analysis of the structure and dynamics of design-based activities, some results and conceptual framing they put forward are particularly helpful to our project. Two particular issues are central here. First, as with much research on the quality of students’ science classroom discussion, McNeill and Pimentel define a measure of dialogicality to capture the degree of direct interchanges between students—i.e., the extent to which students’ talk is responsive to each other’s contributions (rather than, say, talking past each other). Thus, a concern with the dialogicality of students’ contributions means a concern with both students’ ability to articulate positions clearly and to address their peers’ positions, as in professional science. Dialogicality among students’ turns-at-talk will be one of the parameters we will use to characterize the discourse of representational design activities.

Second, as we will see, when it comes to analyzing the structure of any argument-like form of discourse in our activities, we follow McNeill and Pimentel (2009) and many others who research scientific argumentation classroom discourse (e.g., Osborne et al. 2004) in adapting the Toulmin model of argumentation for the task (Toulmin 2003). We emphasize that our goal is not to evaluate, and much less to advocate for, the use of Toulmin’s schema as a standard of argumentation; rather, we seek simply to maintain consistency with the large, existing research base that relies on the schema as a tool of both analysis and design of classroom interventions (Cavagnetto 2010), and thus more readily engage the kinds of analytical comparisons that enrich our understanding of how any particular epistemological discourse practice may be differentially instantiated across types of activities. We will return to these points when we consider the Toulmin model in more detail in an upcoming section.
Research context and methods

As previously mentioned, in IG students work on designing pictorial representations of moving objects—say, by drawing several snapshots in time of the object or perhaps by graphing its speed (diSessa et al. 1991). As extensively documented by sociologists of science, inscriptions of various kinds—e.g., diagrams, maps, illustrations, graphs, equations, and tables—are critical to the work of professional techno-science (Latour and Woolgar 1986). Indeed, mathematics and science have developed in part by accumulating representational forms and systems (say, algebra and the Calculus), and techno-scientists continuously design novel forms for new contexts and aims (diSessa and Sherin 2000). IG seeks to engage students in these representational practices while at the same time providing a path for them to articulate more canonical understandings of Cartesian graphs, their properties and contexts of use.

In a typical IG session, students are given only paper, pencil and color markers, and asked to represent a given motion in whichever way they want. The “desert motion” is one such motion scenario, and across our various trials of the activity it has served as the very first task presented to students: “A motorist is speeding across the desert and she’s very thirsty. When she sees a cactus, she stops short to get a drink from it. Then she gets back in her car and drives slowly away” (Sherin 2000).

In small groups or individually, students work for 5–10 min on their designs and then reconvene to take turns presenting their work to the whole class. Each presentation may be followed by clarification questions—e.g., regarding the representational intent of individual elements or whole representations—by either teacher or peers. As we will see in detail, depending on the teacher’s style and goals, students may also engage in considering the relative merits of different representations and/or component parts, perhaps attempting to converge on the best solution to a particular representational problem and context (e.g., how to best show the duration of the stop). Once a round of design and presentation is completed, students are given a more complex motion to represent, and this often leads them to revise their initial solutions.

Figure 1 shows some typical kinds of representational forms that students create in IG activities, all of which depict the desert motion. All examples are taken from sites focal to our analysis. Figure 1a, b are examples of what we call a temporal sequence—i.e., an array of discrete symbols, each of which tells a piece of the motion story. For instance, in Fig. 1a, vertical lines of different sizes are used to represent different speeds of the object, with the horizontal line at the center used to represent the “special case” of zero velocity. The lines that envelope the vertical lines was later added when students discussed how to transform temporal sequences into graphs. Likewise, in Fig. 1b, the different thickness of lines is used with the same representational purpose. The temporal sequences shown here are to be read from left to right, as with many notational conventions—say, some Western written languages or algebraic expressions—although this orientation may change according to the represented motion (e.g., a falling ball of clay often leads to a top-down representational scheme).

Figure 1c shows a Cartesian graph of the desert motion. While in this case the graph is quite standard, in many instances students have graphed non-standard quantities, such as velocity v direction. Finally, Fig. 1d shows a hybrid of Cartesian graphs and drawings. Beginning on the left, Charles has made a graph-like curve showing the car’s slowing speed until it stops at the cactus. He then drew another graph-like curve that shows the car’s increasing speed and ends it with an illustration of the desert meant to contextualize the representation.
We have run several instances of IG activities (see diSessa and Sherin 2000), across a range of grade levels (from 6th to 11th grade) and educational contexts (i.e., in public and private schools, as well as after-school programs and interview settings). For the purposes of initially delineating our theoretical program, however, here we will analyze only two distinct instantiations of the activity. These two instances were selected exactly because they show similarities and differences, in terms of both what and how discourse practices appeared in each enactment, so that comparing and contrasting them affords a more complete picture of the discourse “landscape” and dynamics of IG. The two instantiations of IG that we will report on are the following:

Benson Middle School: The first trial of IG was implemented in a 6th grade class (i.e., 11-year-olds) at a private middle school in Northern California (diSessa et al. 1991). Eight students participated in the class, which was run as an extension to the students’ regular school activities. The unit lasted five class sessions, each about 50 min long. Initially, the activity was meant to serve as a short prelude to an in-depth treatment of Cartesian graphing. Because in the first day students produced an astounding number of representations and cogently considered various issues regarding the trade-offs of these solutions, we decided to extend the activity for the next 4 days. The first day of activities was audio-taped, whereas the other 4 days were video-taped. A graduate student took field notes on site and all student-generated materials were collected. Analyses of these data have appeared in several publications (see diSessa et al. 1991; Sherin 2000; Azevedo, diSessa and Sherin 2012).

University-bound Talent Development Program (UTDP): Extending the research initiated at Benson Middle, in 1997 we developed and taught a 3 weeks long, experimental course whose goal was to introduce students (grades 7–11, i.e., ages ~12 to ~17) to key scientific ideas through the design and use of representational forms, across disciplines and domains. The course was offered as part of a larger University-sponsored after-school enrichment program (UTDP) intended for statewide, upper middle- and high-school students who wished to experiment with non-traditional subject matter. Student enrollment in the course was voluntary and free of charge, and students’ final grades were reported back to their home (public) institutions as elective credits. Nine students participated in the class; all were high school students, with the exception of a seventh grader. Within this context, the IG activity lasted three sessions, each about 70 min long. All UTDP sessions were videotaped and students’ work was collected.

For the purposes of analysis, we will focus on a single day of the activity—namely, the very first day—at both sites. Again, this choice follows from the observation that the patterns of activity and discourse observed on the first day clearly re-occurred in the successive days—something also observed by McNeill and Pimentel (2009) and which led them to the same methodological/analytical decision. Also following McNeill and Pimentel (2009), we are concerned solely with the nature of discourse as it takes place during whole-class dialogue and exchanges. Thus, our analysis will focus exclusively on moments of public, whole-class interactions, and exclude any dialogues that might take place during the design and redesign phases of the activity (in which students work on their representations alone or in small groups). This is consistent with our larger research program in that we seek to theorize those moments of classroom interaction in which the teacher can have the most impact by orchestrating substantive and productive discursive practice among all participants (McNeill and Pimentel 2009).
With the audio and video data of the Benson and UTDP first-day sessions fully transcribed, we then processed these data in different and complementary ways that illustrate the kind of analysis that can advance our theoretical program, as follows: (1) mapping out the discourse practices of IG activities; (2) fully characterizing these discourse practices, for example, by describing their structure and patterns of emergence; and (3) describing the dynamics of IG activities and the teacher’s role in shaping classroom participation and discourse. We elaborate on each in the next three subsections.

Mapping out the discourse practices of design-based activities

To uncover the discourse practices characteristic of IG activities we watched/listened to each tape several times, following along its transcript, and iteratively worked to partition the transcript into segments of talk and interaction that reflected the shared task orientation and focus of attention of the group. This follows from the conversation (Sacks 1972) and interaction analytic perspectives of the study (Jordan and Henderson 1995) and asks: What are students and teacher doing as a whole and how is this reflected in their talk and action?

As an illustration, consider the following episode from Benson Middle in which the teacher and students discuss a student’s (Steve) solution to the problem of showing the length of the stop in the desert motion problem. This excerpt immediately follows a discussion in which students considered each other’s means of representing stop (i.e., velocity zero), so that all participants knew how others had addressed the issue. Steve’s representation is shown in Fig. 2. Note that it shows an incorrect motion pattern—one in which the car overshoots the cactus, stops briefly (shown by a small = sign), backs up to the cactus, stops for a longer period (shown by a larger = sign), and then increasingly speeds away, rather than the assigned “desert motion.” This problem in accuracy had been previously discussed by the group, and here students were content to consider aspects of Steve’s solution that were unaffected by such inaccuracies.

![Fig. 2](image-url) Steve represents a motion in which the car slows down but overshoots the cactus, stops for a brief period (shown by a small = sign), backs up to the cactus, stops for a longer period (shown by a larger = sign), and then increasingly speeds away (Benson, scanned from original)

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1 Ideally, we would rely on video records for all focal sessions at Benson and UTDP. In any case, our analysis here is in no way compromised by the absence of a videotaped record of the Benson session. For one thing, some of the gestural and material components of participants’ activities in that session were recorded in field notes and some of it is recovered here. Second, as we will see, in some cases the content and sequence of Benson participants’ utterances alone were enough for us to retrieve important gestural information in a person’s discourse (e.g., the referent of a pointing action), and we use these inferences to validate our analysis. Third and finally, given the grain size of analysis that we target, all arguments regarding typical gestural and material contributions of participants not captured by the prior two devices can be safely made from video records of UTDP sessions. These points will become clearer in the analysis section.
23:25 (Transcript #1)²

1. Teacher  How about… did anyone show how long he stopped for?
2. Jackie  Well, on the first one I have a little…
3. Brian  Steve’s did…
4. Teacher  Okay, Steve, how does yours show how long he stopped for? (1 s) Okay, the size of the equal sign shows how long [he stopped for?]
5. Andrea  [Well, you wouldn’t look at it and go… Oh, the equal sign means he stopped//
6. Teacher  //Okay… well with an explanation… with an explanation he has a way of showing that it stopped.
7. Andrea  ((inaudible, 1 s)) I don’t know… why is it an equal sign?
8. Student  ((inaudible, 1.5 s))
9. Andrea  Well, why though?
10. Steve  What else are you going to use?
11. Andrea  Well, I mean…
12. Steve  ((much overlapping talk, inaudible 1.5 s)) Okay, I’ll use…
13. Andrea  No, wait… You should use something that relates to the picture ((i.e., representation)).
14. Steve  What relates to this? ((points to his representation))
15. Andrea  I’m just saying… I mean…
16. Steve  If it’s getting smaller and smaller, then two really really small lines/!
17. Andrea  //I’m asking YOU… I mean, I’m just saying something that relates to the picture.
18. Teacher  Well, do you have a suggestion? Anyone? If you don’t personally like the equal sign?

Immediately following the teacher’s query (turn 1), Jackie began to describe her solution (turn 2) but she got cut off by Brian’s claim (turn 3) that Steve had addressed the issue (which suggests that Brian thought that others had not addressed the issue as well as Steve). The teacher then queried Steve (turn 4) and found out about his solution by consulting his representation, which he held up to her—enough to remind her and others that he had used equal signs of different sizes, placed at the points in the car’s trajectory where it stops (Fig. 2).

On turn 5, however, Andrea questioned Steve’s use of equal signs as perhaps arbitrary (given what it meant to represent) and their use would thus compromise the readability of his solution. As we will see, Andrea’s move follows from other similar moves that she and others had taken before, in part modeled by the teacher, so it is not surprising it appeared in this context. Just as importantly, Andrea’s claim is accompanied by her own suggestion for a possible design fix to the problem (turn 13 and 17)—i.e., that a better solution to showing stoppage would maintain greater consistency with other symbols already in use in the representation, a design criterion we might call parsimony (diSessa 2000). The teacher, on her part, first ‘sided’ with Steve (turn 6), but immediately allowed the students to take over ‘sorting out’ the issue. In response, Steve seemed to genuinely attempt to address Andrea’s concerns; and while he could not make much progress with his argument, he did successfully articulate some of his reasoning (turn 16) in direct relation to Andrea’s points. The discussion proceeded beyond the last turn transcribed above (turn 18), though we need not pursue it further.

² Please refer to the Appendix for transcription conventions.
The point to observe is that turns 2–18 constitute an identifiable moment in which, as a whole, participants oriented themselves toward a common goal within the larger flow of the activity—i.e., the goal of assessing the goodness of fit of a particular representational element, as had been done previously that day. That pattern of activity, in turn, is produced in reflexive relation to a specific form of discourse. As we will see in the upcoming analysis, we judged the above episode to represent an instance of arguing discourse because it shares core features with scientific argumentation activities (McNeill and Pimentel 2009). Our first goal is to catalog and describe the various discourse practices that emerge during whole-class periods of IG activity.

Describing the discourse practices of design-based activities

Whatever forms of epistemological discourse practices we come to find in IG, we must simultaneously describe their key features such that comparisons to the discourse of other science activity types can be readily made—an intrinsic aspect of our theoretical program. For some discourse practices, this description will consider the function the practice plays in the flow of the activity and the mechanisms through which it emerges. For others, we will also consider issues of structure. For instance, in the case of arguing discourse, we will structurally analyze students’ utterances in terms of the Toulmin model of argumentation, as prominently done in the field (Cavagnetto 2010). Thus, rather than looking at discourse at the level of one to several turns-at-talk (each of which potentially composed of several utterances, as in the arguing example above), here the grain size of our analysis is the individual utterance, which we will parse into component elements of structure and their relationships.

We will consider specific methods for characterizing each distinct discourse practice of IG when we present the analysis of these practices in the next major section.

The dynamics of IG activities and the teacher’s role in shaping classroom discourse

Having uncovered and characterized the discourse practices of a prototypical design-based science learning activity, we then consider how such practices unfold in action: How do the discourse practices of IG come about and what is their typical dynamics? What is the role of the teacher in shaping and sustaining distinct patterns and dynamics of discourse in IG activities? These questions drive McNeill and Pimentel’s (2009) analysis of a scientific argumentation activity, and pursuing them here continues to afford some uniformity to analytical comparisons that help advance our larger theoretical goal.

To address these questions, we proceeded in the following manner. We began by conducting a counting of the frequency of occurrence of each of the identified discourse practices. We also timed each episode of each discourse practice, so that totaling them gave us a good idea of the import of each in the overall conduct of the activity.

Differences across enactments of IG at Benson and UTDP were clearly visible, so we moved to qualitatively assess the patterns that we uncovered. To do so, we followed the transcripts of both IG sessions and wrote down the temporal unfolding of discourse practices for each session. We then compared and contrasted these patterns of discourse, attempting to explain both similarities and differences. As we did so, it was particularly clear how the teachers’ questioning strategies and pedagogical moves worked to shape different patterns of students’ discourse, within a common space of possibilities. To probe the issue further, we then coded all teachers’ turns-at-talk for what they achieved functionally during the public moments of exchange (i.e., the whole-class discussion). Particularly useful here were the notions of revoicing (O’Connor and Michaels 1996) and open-/closed-questioning (McNeill and Pimentel 2009), as we will see next.
Analysis and results

As described elsewhere, students’ material production in IG activities is universally high (Sherin 2000). Indeed, across several trials of the activity, students’ have shown great ability to create novel representational forms and to appropriate those created by others, all the while considering important issues of scientific and mathematical relevance. The examples shown throughout the paper and elsewhere (e.g., Sherin 2000) stand as evidence of the richness of students’ contributions, across contexts of implementation.

As we will see, however, the whole-class discourse practices that develop in and around the creation/refinement of these representational forms may vary somewhat across enactments of the activity. This does not preclude us from pinning down the overall discourse practices characteristic of IG, though. In fact, as we will see, it is by explaining how both common and contrasting patterns of discourse emerge in each enactment of the activity that we converge on a more coherent and complete characterization of these practices.

The discourse practices of IG activities

IG activities are dominated by three distinct, but closely linked discourse practices: describing, explaining, and arguing. Describing and explaining discourses appeared at both Benson Middle and UTDP implementations of the activity, but arguing appeared only at Benson. As we briefly mentioned, we trace this difference to a specific teacher move that creates conditions for arguing discourse to emerge. In the context of IG (and other design-based) activities, however, arguing is the main means of assessing the relative merits of solutions (which guide further design refinements) and its absence must indeed be an exception (rather than the rule). Before we consider these points in more detail, we first characterize and illustrate each such discourse practice of IG at some length.

Describing

Describing is the first discourse practice characteristic of IG activities. As used here, describing refers to a student’s public introduction and presentation of his/her design/representational form. Describing thus follows naturally from the flow of IG activities and it is seen in students’ turn taking to present their solutions to the whole group. Functionally, describing arises from the need to communicate how one’s design addresses the representational problems posed in the task, and it sets the stage for whole-class considerations of design trade-offs that drive students’ subsequent refinement of their creations. Far from being a simple ‘narrative’ on the representation, thus, describing in IG consists in an artful selection of representational attributes and aspects that one judges to need description (Goodwin and Goodwin 1996)—a fact that illustrates the complex reasoning involved in describing practices.

As an example, consider Mira’s (UTDP) describing of her Triangles representation of the desert motion (Fig. 3). Mira was fifth in line when it came to showing her solution.

11:33 (Transcript #2)

Mira: Okay, I have triangles and the triangles ((sweeps finger back and forth between 2nd and 3rd triangles))… it’s all one shape and the triangles represent speed and like, the rate… the colors represent different rates. The triangles all represent speed, so as you can see in the middle ((points to circle in the middle of the picture)), that’s where she stops because it’s a different shape… so it’s a circle. It starts off by sections of different colors
and that’s how fast she’s going and the size is getting... it decreases, that means she’s slowing down and then it increases again ((points to triangle on the far right)).

From the beginning, Mira focused on elucidating the representational intent of individual elements in her representation, linking them to the specific aspects of the referent that her representation picked out. In particular, Mira described (1) how triangles are used to represent speed and (2) how the size of each triangle represents the magnitude of the referent’s velocity at certain points in the trajectory, with the special case of velocity = zero (i.e., stopped) shown by a circle. Mira also used the color attribute of the triangles to represent the rate of change of some physical quantity, although the exact meaning of that statement was left unelaborated by Mira and unaddressed by other participants.

In spite of that, Mira’s description is quite complete and students had no trouble understanding her representation. In fact, when looked across all instances of describing in our data, Mira’s is relatively longer (i.e., wordier) than others. Often, at both UTDP and Benson, students provided relatively telegraphic descriptions of their representations, as in the following example in which Althea (UTDP) describes her solution to the desert motion task (refer to Fig. 4). Althea was the sixth to present (i.e., next in line from Mira).

12:37 (Transcript #3)

Althea: Um, I sort of just used the arrows like he did ((points to Steve, who was third in the order of presentation)). Actually, the closer my arrows are together, the faster the speed. So right here ((points to first few arrows on the left of paper)) it’s pretty even until she comes to the stop and then she accelerates right here ((points to arrows immediately after triangle)).
following the stop)), and then it evens out to about the same rate she was going before ((points to arrows on the right)).

While Althea’s describing of her representation is relatively terse, it communicates complex meaning in effective ways. How did she do it? To begin, just like Mira, Althea could rely on participants’ shared understanding of the problem space and its solutions (Goel and Pirolli 1992). In addition, she could also draw on the prior history of student presentations, given her intermediary position in the presentation round. On this shared context, Althea then began by referring to Steve’s representation. Steve was third in line and he too produced a temporal sequence in which arrows were used to represent speed. By strategically invoking Steve’s solution, Althea contextualized and specified her design solution, and simplified her job of describing it.

Having leveraged Steve’s solution as an analogy for her solution, Althea then moved on to highlight how her representation differed from his—a crucial distinction in how her representation must be read, and consequently what meaning must be derived from it. Specifically, rather than using the relative length of arrows to represent different speeds, as Steve had done, Althea’s representation uses the relative density of arrows with the same representational intent, as she states in her second utterance: “Actually, the closer my arrows are together, the faster the speed.”

Finally, to illustrate this point, Althea then ‘walked over’ the representation with her indicator finger, highlighting landmark changes in the object’s speed relative to the density of arrows in the paper: “So right here ((points to first few arrows on the left of paper)) it’s pretty even until she comes to the stop and then she accelerates right here ((points to arrows immediately following the stop))…” Note the heavy use of pointing and gestures here, which highlights how describing discourse in representational design activities (and probably other design-based activities as well) is imminently a process of coordinating multiple modalities of representation—talk, pointing, and material artifacts (here, pictorial and graphic forms)—to communicate meanings that extend beyond what any of these modalities might achieve individually (Hall and Stevens 1995). Central to this process, the permanence of many designed artifacts in media such as the blackboard and paper makes it possible for students to retrieve and use resources that emerge during discussions, and which afford complex meaning making that is not reducible to linguistic phenomena (Goodwin 2000).

Explaining

Explaining is a discourse practice whose function is to explicate something in greater detail (say, a feature of a representational form) or to further confirm understanding from peers and teacher. As such, explaining discourse most commonly follows describing episodes but may also appear during arguing episodes (see next section). Explaining should not be confused with explanation (Berland and Reiser 2009), which in the context of science learning activities usually refers to the culmination of theoretical articulation (e.g., the explanation of the full set of data and observations in an experiment).

To exemplify explaining discourse in IG, consider the following passage in which Althea is called to expand on particular aspects of her representation. The excerpt starts immediately after Althea had finished describing her representation, which was a temporal sequence in which the relative density of arrows represented different velocities of the object (Fig. 4), as considered above.

12:59 (Transcript #4)
1. Mr. E I see. So what was the thing about the arrows being closer together or further apart?
2. Althea The closer they were together… that was the faster the speed. And the way they’re spread apart, that’s the slower speed, I guess.
3. Mr. E So when they’re more spread out, that means slower.
4. Althea Right, right.
5. Mr. E Okay. So the idea here is that like… denser arrows mean faster, or something?
6. Althea Right.
7. Mr. E Okay, I think I get that. Cool. How did you show the stopping?
8. Althea The stopping… I put just like a straight line because there’s no movement so… like, there’s no point in putting an arrow indicating motion or anything.
9. Mr. E Because there’s no motion.
10. Althea Yes.
11. Mr. E I see. And then the cactus is there to remind why they’re stopping or something.
12. Althea Right.
13. Mr. E Cool, great. Okay it looks like yours has two:…. Meena?

This segment is typical of explaining events in IG. First, it is initiated by the teacher (turn 1) and it follows from his goal of highlighting the unique aspects of Althea’s representation, in preparation for a round of design revisions. While students do sporadically request these kinds of elaborations from others, by and large our enactments of IG have had these questions asked by the teacher. We do not know exactly why this might be the case. On one hand, it may just be that engaging explaining discourse takes more time to learn than a single class period analyzed here. On the other hand, it is possible that students take the meaning of some of these representations to be self-evident, and therefore see no reason to seek further clarification from others. Who ever the initiator, explaining episodes play an important role in the flow of IG activities.

Note that throughout the episode the teacher zeroed into the specific features of Althea’s representation that contrasted with previous solutions, rather than focusing on more generic aspects of her solution. He did so by revoicing Althea’s utterances, in effect amplifying her reasoning, her use of multiple symbols, and so on (O’Connor and Michaels 1996). In turn 1, the teacher bracketed Althea’s distinct use of the density of arrows as representational device. And in turn 7, he picked out Althea’s use of a line (i.e., a distinct representational element within Althea’s ‘system’ of arrows) to signify velocity zero. In both turns, the teacher revoicing moves opened the possibility that Althea might elaborate her initial description and further drew her into the ongoing dialogue (O’Connor and Michaels 1996).

Lastly, as with describing practices in IG, explaining is heavily tied to the coordination of talk, pointing and gesturing over the various designed representations—both one’s own and those of others’, which are opportunistically called upon as a well understood example—which further underscores the material quality of discourse practices in these activities.

**Arguing**

Finally, arguing is also a discourse practice that prominently appears in IG activities (though not homogeneously across Benson and UTDP sessions, as we will consider in the
next section). By arguing we mean to refer to a kind of discourse practice that shares many features with forms of argumentation characteristic of scientific argumentation activities—such as our central comparison case (i.e., McNeill and Pimentel 2009) and others (e.g., Osborne et al. 2004)—and critical discussions (Andriessen 2006). As an illustration, consider the following excerpt from Benson Middle in which the class discusses the relative qualities of a representation created by one student (Mitchell). The excerpt starts with Mitchell describing two solutions to the problem of representing the desert motion, but students’ arguing immediately focused on his second solution/representation, which uses the degree of inclination of a line to represent different speeds (Fig. 5). Briefly, in Mitchell’s scheme—later named Slants—a vertical line represents a stop (velocity zero) and a horizontal line represents “as fast it can go,” as he would explain later in the session.

14:30 (Transcript #5)

1. Mitchell My first one’s a lot like Brian’s where the farther apart the dots are sort of uh:: you know the::: the faster it goes, and then there’s a little line here that represents a stop. And then the second one, which I like better is: alright if the line is horizontal, he’s going really really fast. And the fur… and the further up the line slants, the slower it goes, and then when it gets like this ((a vertical line)), it stops. So it goes all the way and then in the middle of the line stops, and then it goes like… and then it goes like that.

2. Student I like that one ((Slants)).

3. Teacher Why do you like that one better? Or why do you like that one?

4. Andrea Well my only problem with that is… I think it’s a really good idea and stuff, the only problem is… if someone was to look at it, they’d look at it and go… ok::ay, what does that mean?

5. Chuck If you said one sentence you’d know exactly what it was. ((much overlapping talk, inaudible, 3 s))

6. Chuck You can tell that something’s changing.

7. Mitchell You can tell how it’s changing ((inaudible))… try to interpret ((inaudible))

8. Chuck If you said SPEED you’d understand, like this ((a slanted line)) is either slowing down or speeding up

9.

10. Student ((Lots of overlapping background comments))

11. Mitchell I can even use a phrase: Line horizontal slow… [fast line vertical

12. Andrea [((Complains, inaudible))]}

13. Mitchell I can have a key, I can even go… in this key I can go…

14. ? … ((Lots of overlapping talk, inaudible, 16 s))

15. Andrea If someone said speed and… that…to me…he explained it so I get it…

16. Teacher Okay, that’s good.

Following Mitchell’s describing of both of his representations, on turn 2 a student then declared that he liked Mitchell’s second representation (Slants). This student’s evaluative remark likely followed from previous teacher moves that sought to evaluate different design solutions, so that publicly declaring ‘preferences’ for design solutions had been modeled before. Turn 3, this time by the teacher, crystallizes this direction for the
conversation; if followed by students, it might have led to their comparing and contrasting existing representations, as had happened before. However, immediately following the teacher’s questions (turn 3), Andrea (turn 4) took issue with some aspects of Slants, suggesting that the representation might be opaque to some audiences—technically, a call for a criterion akin to the readability of scientific representations and their conventions, a common concern in the crafting of professional scientific representations (Tufte 1990). Andrea’s comments, in turn, sparked a heated argument—as seen, for instance, in the relative frequency of overlapping talk—and from turns 4–15 students then added arguments in favor and against Slants. On turn 16, the teacher extinguished the argument so that students who had yet to describe their solutions could have their turn.

On this background, we can now better understand the core features that make this and other similar episodes instances of arguing. First, as with scientific argumentation and critical discussions activity structures, arguing emerges from the problem/activity affording opposing or contrasting solutions, which students’ can then take on to defend or to counter. While in scientific argumentation activities students often discuss two opposing theories (e.g., McNeill and Pimentel 2009), in IG students argue over competing—but not necessarily opposite and mutually exclusive—representational design solutions. Alternatively, as in the excerpt above, students may engage in evaluative comments regarding a single representation, which does not necessarily lead to a clear opposition between viewpoints either, but just enough difference in viewpoints/solutions to motivate a pattern typical of arguing dialogue in which students defend positions and attempt to persuade/weaken others. In the episode above, we see that some students’ argumentative contributions in fact add to the evolution of the design of Slants (e.g., as in turn 13, where Mitchell suggests adding a “key” to further specify the meaning of slanted lines). In this regard, as in many characterizations of scientific argumentative practices, students arguing in IG often functioned as a form of dialogue in which students attempted to reason together and effectively ‘got somewhere,’ materially and conceptually (Scardamalia and Bereiter 2006).

Second and also critically, throughout the exchange students did successfully address each other’s positions—rather than ‘arguing’ past each other—in effect engaging in true argument and counter-argument that is a core aspect of argument-centered science classroom activities. As we have seen, in McNeill and Pimentel’s (2009) case this measure of “inter-connection” between students’ argumentative utterances is operationalized as the dialogicality of their contributions and it is shown to vary according to teachers’ questioning strategies. In this regard, as in many characterizations of scientific argumentative practices, students arguing in IG often functioned as a form of dialogue in which students attempted to reason together and effectively ‘got somewhere,’ materially and conceptually (Scardamalia and Bereiter 2006).

Some differences emerge when we attend to the structural details of students’ utterances in IG and how those contrast to their counterparts in argument-centered classroom activities. Intuitively, designing paper-and-pencil representations of moving objects (as in IG) is an activity that is relatively different from arguing about various explanatory theories, so it is to be expected that structural features of argumentative discourse will vary across these kinds of activities. To illustrate these points, we follow a trend in the literature on scientific argumentation classroom discourse (again, see Cavagnetto 2010 for a thorough review) and use the Toulmin model of argumentation as a tentative tool for characterizing arguing in IG activities. While there are disagreements regarding the appropriateness of the model for assessing the quality of students’ classroom argumentative discourse (see discussion in Bricker and Bell 2008), its use here serves our larger theoretical goal of characterizing the structural similarities and differences in arguing discourse across science classroom activity types.
In essence, the Toulmin model provides a framework for analyzing the structure of an argument and potentially its quality (Toulmin 2003). An argument in the Toulmin schema is understood in terms of a set of interrelated structural elements: (1) claims, (2) grounds (i.e., evidence or data), (3) warrants (i.e., justifications for linking specific data to specific claims), (4) backings (i.e., more general reasons for deploying such warrants), (5) modal qualifiers (e.g., "usually"), and (6) rebuttals to conclusions. A Toulmin analysis of students’ argumentative discourse thus consists in parsing students’ utterances into these structural elements and assessing whether they appear in proper relationships (e.g., whether the grounds for one’s position indeed addresses his/her claims).

In McNeill and Pimentel’s (2009) case—in which students argued for and against two theories of climate change—a claim advanced by a student might be: “I would say global warming is occurring” (p. 211). Similarly, an instance of evidence that supports such a claim might be “I was going to say that, um, the waters have risen” (p. 211). As for warrants and backings, McNeill and Pimentel collapse these formal structures into a single element named reasoning—a “measure” of how students could use either or both warrants and backings to justify their moves from claim to evidence. An example of reasoning might be: “Because we use so much μm gas and stuff and cities, like cities use a lot of carbon dioxide… their atmosphere is open and bigger” (p. 211).

Shifting back to the Benson Middle episode of arguing above, what might a Toulmin analysis reveal regarding similarities and differences across activity types? Beginning in turn 2 (Transcript #5), and considering the prior history of the activity, an anonymous student’s made a claim that, in his judgment, the Slants representation is indeed a good solution to the problem. It is, therefore, an evaluative claim regarding (at least part of) the existing pool of representations, and in this context it is hard to imagine what the student might offer as evidence (or data) backing up his claim. (Indeed, what might be properly called an evidence for one’s design choice?) More likely, the student might have advanced some justification for his design assessment—that is, the reasoning element, seen as an articulation of warrants and backings in Toulmin’s schema, as McNeill and Pimentel (2009) characterize it—and which is central to scientific argumentation.

Before the student could elaborate on his claim, however, on turn 4 Andrea put forward another evaluative claim, this one calling into question the readability of Slants (as we have seen). While Andrea’s turn at talk is relatively long, as in the previous student’s turn (turn 2) it does not suggest or point to anything exactly like a piece of evidence/data that might back up her claim. And yet, Andrea’s claim has profound and clear meaning to participants—so much so that it elicits counter-arguments from Charles, Mitchell, and others (turns 5–15). Indeed, in the flow of activity, Andrea’s statement is a challenge to Slants representational adequacy and it embeds a complex reasoning about the problem and its solution. Andrea’s reasoning is left mostly implicit, and at least parts of it are done by the Slants representation itself, which persists on the board for all to see. By the same token, part of Andrea’s discursive reasoning is done by the Slants representation (originally conceived by Mitchell) and perhaps all other representations presented up to that point. As in describing and explaining discourse practices in IG, then, meaning in arguing episodes is made out of a complex coordination of expressive modalities, including talk, gestures, and a variety of representational forms that are at the center of the design goal of the activity.

Turns 6 and 7 helped solidify this point. In both, students added claims and reasoning regarding aspects of Slants that they believe are clearly readable—and thus addressed Andrea’s original concern. But these claims and justifications/reasoning critically stand in the presence of Slants, which does part of the talking and which further exemplifies the
materiality of arguing practices in IG (and likely other design-based activities, given their artifact-centered nature).

In all, arguing in IG shares much with the discourse practices of scientific argumentation activities, both in terms of dynamics and structure. In spite of structural similarities, differences also exist, as revealed by a Toulmin structural analysis of IG arguing discourse. These differences are borne out of the distinct goals, demands, and mediational means of design-based activities (IG, in this case), as contrasted to theory-building discourse of argumentation, which again highlights the domain-specific nature of argumentation practices (Bricker and Bell 2008). Put simply, designing and improving a representational artifact is not exactly like coordinating claims, evidence, and justifications for one’s positions—although discussing these artifacts’ design trade-offs might lead to arguing discourse that retains some form of claims-and-justification discourse typical of scientific argumentation activities. Given the artifact-centered nature of the activity, relative to scientific argumentation activities, arguing (and the reasoning it entails) in IG includes a significant component of representational practices (Hall 1996). In this regard, our work begins to address Leah Bricker and Phillip Bell’s (2008) suggestion that research on science classroom argumentation focus on the inscriptive aspects of this discourse practice.

The dynamics of discourse in IG and the teacher’s role in shaping it

As a final step in characterizing the discourse of design-based activities, we now consider the dynamic unfolding of discourse practices across both IG implementations. Patterns in the manifestation of discourse practices varied across sites, and we explain these differences by linking them to the presence/absence of a specific teacher questioning strategy.

We begin by summarizing some numerical measures of frequency of discourse practices across sessions. At Benson Middle, there were 8 episodes of describing, 7 episodes of explaining, and 7 episodes of arguing. The total time the class spent in each of these discourse practices amounted to 4:04 (minutes and seconds), 5:26, and 10:05, respectively, which in turn correspond to 15.6, 20.9, and 38.7 % of total whole-class discourse, respectively. Having used much time arguing about design solutions, the whole-class portion of the first IG session at Benson turned out longer than planned and students did not have time to engage in a second round of designs (i.e., redesign).

In the UTDP session, in contrast, there were 12 episodes of describing, 11 episodes of explaining, and no episodes of arguing. (We did record one episode of arguing at UTDP, but it took place among members of a group while they worked on re-designing their representation and discussed their ideas with the teacher—i.e., outside the public, whole-class sphere of discourse that is our analytical focus). The total time the class spent in describing and explaining practices amounted to 4:50 (minutes and seconds) and 4:29, respectively, which in turn correspond to 34.8 and 32.3 % of total whole-class interaction. Having spent no time arguing their design solutions, in the UTDP session students proceeded to a second round of designs in the first day.

Dynamically, the unfolding of discourse practices at the UTDP session followed the pattern $D-E-D-E-D-E...$ (where $D =$ describing; $E =$ explaining; $A =$ arguing)—that is, students and teacher alternated between describing and explaining their representations, but did not argue about the trade-offs involved in different solutions. In contrast, the Benson session had a pattern $D-E-D-E-D-E-A...$ $D-E-D-E-A...$, in which arguing appeared throughout the session, as a way to evaluate the relative qualities of existing solutions and to generate parameters for design refinements, as we saw above.
To account for these differences, we find it useful to begin with a discussion of plausible explanations. In theory, given the demands of the cycle and process of design, it makes sense that whole-class discourse in a design-based activity unfolds along a pattern of description, explanation, and arguing, followed by further design rounds. In other words, in IG it is sensible that some design solutions must be first described and their representational intent and details perhaps elaborated (i.e., explained), and once enough distinct representations are accumulated, students and teacher might then proceed to argue the artifacts’ relative qualities and to generate parameters for design improvements. A new design/refine cycle would then ensue.

From this perspective, then, we must explain why arguing did not surface as a practice in the UTDP session, rather than explicating why it did appear so much at Benson. Put differently, design must “naturally” include some form of artifact assessment (Brophy et al. 2008), so its absence must somehow be explained. As extensively documented, given the hierarchical organization of schools, classroom discourse is heavily shaped by teachers’ agendas and decisions. In McNeill and Pimentel’s (2009) study of argumentation practices, for example, the more teachers asked open-ended questions, rather than close-ended ones, the more students succeeded in articulating claims, evidence and justifications/reasoning into coherent arguments. In their scheme, open-ended questions are those that allow for a variety of possible answers (rather than a specific answer known by the teacher), whereas close-ended ones are those with a very limited number of correct answers.

As we seek to explain the emergence (or not) of practices of describing, explaining, and arguing in IG activities, we find that teachers’ pedagogical moves are not adequately captured by conceptual categories such as open- and close-ended questions. Specifically, as we focus our lens on the dynamics of discourse at Benson, we see that teacher’s utterances prior to arguing episodes contained (one or more instances of) what we termed argument-leading questions—i.e., questions that create distinctions between different design solutions and which therefore call for a resolution through arguing. In this regard, argument-leading questions function much like opposing theories do in scientific argumentation activity structures (McNeill and Pimentel 2009). To illustrate, the fourth episode of arguing at Benson started with the following argument leading question from the teacher:

20:04 (Transcript #6)
Teacher: Okay, let’s figure out whose is the simplest. Whose is the simplest? Which ones tend to be the simplest? Which one could you just show someone and they’d say… Ah, I get it, I see. Which one could stand by itself?

The question was asked immediately after the last student had presented her solution and it was meant both to wrap up the current design round and to raise design problems, in preparation for the next round. While this can be done in many different ways, as posed by the teacher the questions unmistakably functioned to create a number of contrasts among existing representations, and that triggered arguing around rich issues of scientific representational design.

Two additional examples of argument leading questions appeared previously. In the first, the teacher directed students’ attention to the problem of representing stopping (“Whose pictures [representations] show the stopping?”), while in the second she called for an evaluation of a specific representation (“Why do you like that one better? Or why do you like that one?”). In both instances, her move effectively created alignments and contrasts between representations (or parts thereof), which then led to an argument/counterargument pattern of discourse.

At UTDP, on the other hand, we find that 51 % of all teacher’s turns-at-talk were revoicing moves that either rebroadcast or explained students’ ideas (O’Connor and...
Michaels 1996), and which therefore never modeled to students the kinds of evaluative moves/argument-leading questions observed at Benson. This needs not be the case, however, as revoicing often works to create alignments and oppositions among solutions (O’Connor and Michaels 1996) and thus can critically foster arguing. As enacted at UTDP, teacher’s revoicing moves still served important functions within the flow of the activity. But lacking the critical argument-leading questions, oppositions and alignments between students’ design ideas were not directly treated in public discourse (For a canonical example of revoicing at UTDP, please refer to Transcript #4).

How have we done? Assessing progress towards the theoretical program

This paper is an initial contribution to a general theory of the intersection between science classroom activity types and discourse practices. Appropriately, here our goals have been humble; basically, we sought to outline the theoretical program and to begin detailing its development with an analysis of the discourse of a specific classroom activity type (namely, design-based). The analysis highlighted key dimensions of discourse and activity, including the epistemological discourse practices that characterize the activity’s core, their function, structure and dynamics, the typical patterns in which these discourses unfold in action, and the influence of the teacher in shaping such patterns. The natural development of the theoretical program is to carry out the same kind of analysis to other activity types (such as scientific inquiry and modeling), beginning with prototypical instances of each and continuously building on the established analytical bases.

As we assess our progress thus far, recall that our initial motivation for bringing together science classroom activities and discourse follow from various socio-cultural traditions of research that frame activity and discourse as mutually constitutive (Goodwin 2000) (See also Jordan and Henderson 1995). Language is a primary medium through which participants in a setting construct and reconstruct their joint activity (Goodwin and Goodwin 1998) and make sense of their collective goals (Sacks 1972).

At the same time, activities have intrinsic demands that reflect their deep nature and participants’ continuous negotiations of such demands define the patterned pursuits typical of any single activity (Rogoff 1995). In tailor shops in Liberia, for example, requirements of garment production are addressed within different phases, each of which patterned after specific goals that participants share and reconstruct (Lave and Wenger 1991). In street candy selling (Saxe 1991), regularities in the mathematical practices of sellers reflect the process of buying the goods from distributors, pricing them at a profit, and finally selling them to the public. More in line with our concerns, in the science classroom different types (or genres) of activities are readily discernible and grow out of cultural traditions that have historically shaped both the scientific enterprise itself (e.g., Pickering 1995) and its translation into Western modes of schooling (Lave 1988).

So what might we learn from our larger program, given the above analyses and initial program outline? By linking patterned classroom pursuits to attendant discourse practices, across different types of activities, we effectively create a map in which general and specific features of discourse qua activity can be readily compared and contrasted. As we populate our map with analyses of various other activities, we may zoom into any single science activity category (e.g., scientific argumentation or modeling) to see the epistemological discourse practices of prototypical cases of the category and, as we move out from the “center” of the category, the many variations in discursive practices that spring from “add-ons” to its basic implementation. As we zoom further out to consider several
distinct activity types, we can see the broader epistemological discursive space (including their content and dynamics) of science classroom activities, and how various activities are discursively distinct on some fundamental, but also subtle ways. Of course, the comparisons and contrasts afforded by such a map are not meant as a form of assessment of the quality of science classroom activities (or activity type); rather, we intend them to reveal new insights into the nature of both science classroom activities and discourse, and to use these insights as means to aiding classroom practice. Here we list some such insights.

At the most basic level, our analysis of IG discourse (and its contrast to scientific argumentation) shows that epistemological discourse practices vary across activity categories/types. In addition, in some activity types (e.g., design-based) discourse practices may be multiple, whereas in other activity types (e.g., scientific argumentation) a specific form of discourse may strongly dominate. That discourse practices vary across activity contexts is to be expected (Lave and Wenger 1991) (See also Jordan and Henderson 1995). But our map helps put into perspective the broader space of epistemological discourse practices of science activities, so we can better appreciate the richness and variety of discourse practices typically afforded by different activity types and better consider their practical import for specific science classroom situations.

Furthermore, the map shows that any single discourse practice may be differentially instantiated across science classroom activity types—another example of the context-sensitive nature of activities (Lave and Wenger 1991). Arguing discourse, for example, appears in somewhat different versions across prototypical instances of design-based and scientific argumentation activity structures, and it may well appear in activities such as model building and scientific inquiry, given the evaluative components often embedded in the flow of these activities (Lehrer and Schauble 2005). Scientific inquiry and model building activities may indeed recruit some of the same forms of epistemological discourse practices appearing in IG-like activities (e.g., describing and explaining discourses), but also some novel discursive forms that reflect those activities’ specific nature. What a theory of the intersection between activity types and discourse practices provides is a framework for exploring these distinct instantiations of classroom epistemological discourse practices and adds texture to how we understand any single form (e.g., argumentation) of science classroom discourse. Pragmatically, this allows us to fine-tune science classroom learning by weaving combinations of activities throughout the curriculum, based on pupils’ developing discursive competencies.

Digging more deeply, we see that just as the demands of an activity shape its patterns of enactment and discourse, so do the material goals and means of the given activity (Goodwin 2000) (See also Saxe 1991). As we saw in the above analyses, depending on the type of science classroom activities, participants’ discourse hinged to a greater or lesser extent on the material basis of the activity and what was done to these materials (as stemming from the requirements of the activity). In McNeill and Pimentel (2009), for instance, discourse assumed a material character when students and teacher “talked with” the theories and evidence they learned from the movies (say, in their discursive references to film images and graphs) that they watched prior to the whole-class discussion. This seems to be amplified in design-based activities, given their artifact-centered nature, and discourse practices in IG are heavily tied to the designs that students create and refine. Indeed, in a very real sense, in IG the representations do a significant part of the talking and students’ describing, explaining, and arguing discourses can only be understood in the presence of the various representations that they create (see Goodwin 1994). While the materiality of discourse has been widely studied by conversation analysts (Goodwin 2000) and educators working from a broader socio-cultural framework (e.g., Stevens 2000),
juxtaposing different activity types puts into relief how the different degrees of materiality in students’ talk may affect their ability to effectively participate in any given activity.

By the same token, the permanence and public availability of these artifacts supported students directly addressing and building on each other’s discursive and material contributions, in effect sustaining the dialogicality of students’ exchanges. Just as pilots in jet airliners address each other’s turn-at-talk by reference to shared representations and instruments in the cockpit (Hutchins 1995), in IG students’ designs ground their conversations such that addressing each others’ position is part-and-parcel of the activity. Our map would eventually compile information on how dialogicality is differentially achieved across activity types and thus provide teachers a tool to both evaluate ongoing classroom activities and design novel interventions.

On the flip side, our theoretical progress leads to insights into its own limitations. To begin, for as much as a general theory of the intersection between activity types and discourse practices might have to offer to science classroom practice, by definition such a theory touches only partly on issues of learning. Specifically, in both the analysis above and McNeill and Pimentel (2009), the exact meaning of participants’ utterances during the activities—and by implication the nature of students’ learning—is only partly considered. Of course, this does not detract from our efforts, but rather reminds us of the theoretical space intentionally left out our project. Furthermore, following the socio-cultural framing at the core of our work (Lave and Wenger 1991), participation and discourse are reflexively related to knowing and learning, and thus considerations about students’ learning should be a natural outgrowth of our project.

An additional, potential limitation in our work concerns our assumptions regarding what constitutes truly prototypical instances of science classroom activities. Specifically, while IG activities and McNeill and Pimentel’s (2009) scientific argumentation classes appear to be good prototypes of their respective categories, it is plausible that further research will uncover other activities that more closely approximate the “center” of such categories. Again, as with our previous comment, we do not see this as an implicit weakness of our work; rather, we believe that this is part and parcel of the process of theory development, one which self-corrects with extended investigation and the scrutiny of the research community. In any event, even if newfound instances of design-based and scientific argumentation activities are judged as better prototypes than the ones considered above, our analysis of IG and McNeill and Pimentel’s (2009) activities will still serve as contrasting cases that add texture to our developing understanding of inter- and intra-category variations in discourse—the ultimate goal of our project.

Likewise, our use of the Toulmin schema as a tool for characterizing the structure of students’ argumentative discourse may be seen as dubious from some perspectives (e.g., Simosi 2003). While the expedient has brought us some quick practical and theoretical gains, the question remains as to whether the use of Toulmin’s model as an evaluative tool of students’ discourse obscures more than illuminates the nature of science classroom argumentation (see the extended discussion in Bricker and Bell 2008). We emphasize that our choice has been strategic, rather than an endorsement of a specific form of structural analysis of science classroom discourse. Indeed, we believe our theoretical program itself may inform the discussion as to what scheme may best be suited for a structural analysis of students’ argumentative discourse, the advantages and limitations of each scheme, and so on. For instance, as we suggested above, as we develop knowledge of how students’ argumentative discourse varies in structure across classroom activity types, we add to our understanding of the context-sensitive nature of science classroom discourse.
Concluding thoughts

In closing, we believe we have taken some positive initial steps toward theorizing the intersection between science classroom activity types and discourse practices. Perhaps more importantly, we believe we have shown that the general theory we propose is a feasible and worthwhile pursuit. In particular, the expedient of analyzing prototypical activity instances facilitates generative and piecewise theory building, and suggests many clear directions for future pursuits. For example, a natural next step in the project would involve documenting the discourse practices of scientific modeling and scientific inquiry activities, comparing and contrasting them to discourse practices and patterns documented here and elsewhere (e.g., Engle and Conant 2002). Likewise, we will learn much by investigating the discourse practices of design-based activities whose activity structures involve longer and more intricate design cycles than that of representational design activities analyzed here (e.g., Fortus et al. 2004), as well as those that involve longer and more intricate sequences in scientific argumentation (Osborne, Erduran and Simon 2004).

Pragmatically, even an initial documenting of discourse practices in prototypical activities seems to help further our goals of aiding rich pedagogical discourse in science classrooms. For instance, we can see clearly that different activity types generally support specific sets of discourse practices (e.g., describing, explaining and arguing in design-based activities and arguing in scientific argumentation ones), and that overlapping discourse practices across activities show different characteristics (e.g., arguing is slightly different across design-based and scientific argumentation activities). As we add more exemplars to our database of analyses, we further add to science teachers’ ability to select, combine, and tailor activities to the discursive needs and strengths of students. We hope our arguments will attract others to this pursuit.

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Appendix

We use the following conventions in the transcription of participants’ talk (adapted from Hall & Stevens 1995):

. . . Ellipses show a pause of less than three seconds
:: Extended vowel sound (e.g., No::)
(( ))) Authors’ comments or description of activity
[ Beginning of overlapping talk
// Indicates no interval between the end of a prior and start of a next piece of talk
unint. Unintelligible talk, with duration indicated if equal to, or greater than 1 sec
caps EMPHATIC talk

References


The discourse of design


Flávio S. Azevedo is an Assistant Professor in the Department of Curriculum and Instruction at the University of Texas at Austin. He has a background in electrical engineering and computer science and a Ph.D. in Science and Mathematics Education from UC Berkeley. His research focuses primarily on theorizing the nature of short- and long-term interests in STEM disciplines, and designing learning environments that are truly engaging to students. This has led him to investigate learning and interest-based participation in both classrooms and hobby practices (model rocketry and amateurs astronomy). Other research interests include the use and creation of technical representations and the way these mediate reasoning; the discourse of engaged participation in STEM classrooms; and social justice issues in STEM education.

Peggy L. Martalock is a doctoral candidate in the department of Teacher Education and Curriculum Studies at University of Massachusetts, Amherst. She has experience designing learning environments for young children that provoke interest and engagement. Research interests include constructions of the young child in society and education; children as citizens; and documentation as a tool to enhance pre-service teachers evolving classroom practices. Her current research explores the nature and qualities of teacher/child interactions in early childhood classrooms, especially those in which the child is positioned as storyteller in curricular activities that support language and the use of narrative.

Tugba Keser is a doctoral candidate in Mathematics, Science and Learning Technologies in the Department of Teacher Education and Curriculum Studies, University of Massachusetts, Amherst. She received BS and MS degrees in Chemistry Education from Bosphorus University, Turkey, and worked as a research assistant in Faculty of Education at Trakya University, Turkey. Her primary research interests include theories of reasoning and learning in science and mathematics education, the integration of technology into teaching and learning, and the use of argumentation discourse in science classrooms.
Perezhivanie and classroom discourse: a cultural–historical perspective on “Discourse of design based science classroom activities”

Megan Adams · Sue March

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Abstract Flavio Azevedo, Peggy Martalock and Tugba Keser challenge the ‘argumentation focus of science lessons’ and propose that through a ‘design-based approach’ emergent conversations with the teacher offer possibilities for different types of discussions to enhance pedagogical discourse in science classrooms. This important paper offers a “preliminary contribution to a general theory” regarding the link between activity types and discourse practices. Azevedo, Martalock and Keser offer a general perspective with a sociocultural framing for analysis of classroom discourse. Interestingly the specific concepts drawn upon are from conversation analysis; there are few sociocultural concepts explored in detail. Therefore, in this article we focus on a cultural historical (Vygotsky in The collected works of L. S. Vygotsky. The history and development of higher mental functions, vol 4. Plenum Press, New York, 1987; The Vygotsky reader. Black, Cambridge, 1994) methodology to explore, analyse and explain how we would use a different theoretical lens. We argue that a cultural historical reading of argumentation in science lessons and design based activity will expand Azevedo, Martalock and Keser’s proposed general theory of activity types and discourse practices. Specifically, we use Lev Vygotsky’s idea of perezhivanie as the unit of analysis to reconceptualise this important paper. We focus on the holistic category of students’ emotional experience through discourse while developing scientific awareness.

Keywords Cultural–historical · Sociocultural · Perezhivanie · Discourse · Classroom science

Forum: This review essay addresses Flavio Azevedo, Peggy Martalock and Tugba Keser’s paper entitled: The discourse of design-based science classroom activities.

Lead Editor: M. Fleer.

M. Adams · S. March
Department of Education, Monash University, McMahons Road, Frankston, Australia
e-mail: megan.adams@monash.edu.au

S. March
e-mail: sue.march@monash.edu
This response paper focuses on using a cultural historical methodology. We begin by offering a brief synopsis of Avezedo, Martalock and Keser’s article and how we see the relation between design activity, discourse and student argumentation as proposed by the authors. We expand this conceptualisation by discussing the relations between the student and their environment as the source of development (Vygotsky 1994). This is further explained by illustrating our understanding of perezhivanie, which is understood as the students’ emotional experiences in the relations between personal characteristics and the social and material environment (Vygotsky 1994). We offer an example of our interpretation of a cultural historical data collection method and analysis. We draw on data provided by Avezedo, Martalock and Keser to illustrate how we would use perezhivanie as the unit of analysis. We explain and illustrate how our method of data collection and analysis differs from the authors’ method. This results in reviewing the questioning discourse offered by the teacher and students, which produces a different focus to that of the authors.

Azevedo, Martalock and Keser’s article seeks to combine activity types and epistemological discourse in science learning environments through the use of case examples, which outline and characterize the discourse practices of a design-based science classroom. Students are tasked with designing pictorial representations of moving objects either individually or in small groups through inventing graphing (IG). On completion of their first design, students are encouraged to present and explain their product to gain feedback in the form of argumentation discourse from peers and the teacher to use in subsequent iterations of the design process. According to Azevedo, Martalock and Keser the importance rests with “aiding rich pedagogical discourse in science classrooms”.

The authors frame and propose an informed argument towards the positive use of students’ iteratively designing and refining an artefact in the context of whole classroom discussion with teacher input, noting that “To engage students in such discourse practices therefore is to provide them with opportunities to participate in core aspects of scientific disciplines” (Azevedo, Martalock and Keser). The authors choose a broad theoretical framework to advocate this point and seek to combine a sociocultural framing with situative frames of learning (Greene 2006), conversation analysis (CA) (Sacks, Schegloff, and Jefferson 1974) and interaction analysis (Jordan and Henderson 1995).

Azevedo, Martalock and Keser consider June Lave and Etienne Wenger’s (1991) sociocultural framing as central to their work and note the reflexive relation between participation, discourse, knowing and learning. The authors acknowledge that student learning should be “a natural outgrowth of [their] project” and challenge others to extend this important point. The focus in Azevedo, Martalock and Keser’s article relates to students’ developing the use of argumentation through activity type and discourse, which we conceptualise in Fig. 1.

In this conceptualization, the students’ experience of the situation is not explicit. We seek to extend this conceptualisation through using Lev Vygotsky’s (1987) cultural historical theory and the concept of perezhivanie. We apply the concept of perezhivanie to the developing scientific awareness evident in the classroom discourse presented in Azevedo, Martalock and Keser’s article. We believe this new focus supports the authors’ informed

Fig. 1  Conceptualisation of discourse as central to the development of student argumentation
position in generating a stronger theoretical basis for an initial general theory in relation to discourse practices and design activity in science classrooms.

Reconceptualising discourse from a cultural–historical perspective

The significance of Vygotsky’s cultural–historical theoretical work for furthering Azevedo, Martalock and Keser’s argument will become clear as we work through an analysis of the discourse of scientific classroom practices in this response. Using a cultural historical reading, the focus is on the dialectical relations between the student and the environment as the source of development (Vygotsky 1994). Development begins in social interaction, learning from and with others and then moves to an individual understanding, where the students can work by themselves and gain scientific understanding and awareness (Vygotsky 1987). Vygotsky (1989) relates emotions, actions and consciousness; Roth (2007) agrees with this argument by stating, “there are inner relations between emotion and practical activity that make the former a constitutive element of the latter” (p. 45). In this response paper it is the students’ relations with practical activity, each other and the teacher that is our main focus.

Vygotsky (1994) discusses the role of the environment in relation to students’ development, using the concept of perezhivanie. In this conception it is the “unity of personal characteristics and situational characteristics” (Vygotsky 1994, p. 341) which comes to the fore. Roth (2007) suggests that emotions have a collective dimension through the individual’s participation in social situations. The individual emotional experience (perezhivanie) of the student is inextricably linked with and formed through, the collective experience of the classroom environment. Reciprocal relations and the ensuing emotions are shaped individually and collectively. A recent study by Jennifer Schmidt, Elena Lyutkh and Lee Shumow (2012) places the idea of perezhivanie in the context of high school science learning and teaching. Here we use this concept to advance the theorization proposed in Azevedo, Martalock and Keser’s article. Our approach considers a holistic interpretation of perezhivanie, in contrast to the tightly framed view of perezhivanie put forward by Schmidt et al. (2012) that attempts to relate students’ subjective experience with teacher discourse. It is noted that important considerations such as teacher personality, experience and relations with students are reduced to ‘compounding variables’ whereas in this response, these aspects are essential to understanding perezhivanie in the classroom situation.

Considering the student and environment as a unity: introducing perezhivanie

Perezhivanie is increasingly used in the original Russian because translation into English does not fully explain its rich and multifaceted nature (for further theorization, see Gonzalez Rey 2009). In this paper we use the concept of perezhivanie as an integral part of Vygotsky’s whole system of concepts (for explanation see Chaiklin 2003). Vygotsky explains perezhivanie:

The emotional experience (perezhivanie) arising from any situation or from any aspect of his [sic] environment determines what kind of influence this situation or this environment will have on the child. Therefore it is not any of the factors in themselves (if taken without reference to the [student] which determines how they will influence the future course of his (sic) development, but the same factors
refracted through the prism of the [student’s] emotional experience (*perezhivanie*). (Vygotsky 1994, p. 339)

The student and the environment (social and material) are considered active agents in the process of meaning making, understanding and consciousness. As Vygotsky (1994) outlines, it is the dialectical relations between these active agents that need to be explored. The student’s *perezhivanie* is an indivisible unity of the situational characteristics (collective) and personal characteristics (individual). It is this unity and the intense emotional nature of students experiencing this unity, that Vygotsky refers to as the “prism” refracting the social and material environment. Thus *perezhivanie* is a collective and an individual concept and one that needs to be explored further in the area of education in general and science education in particular.

The model in Fig. 2 foregrounds the *relations* between the environment and student. These relations are dynamic and change as students move through their everyday lives. Rather than *measuring* the emotional indicators (as was done in the study by Schmidt et al. 2012), Vygotsky’s focus is “finding the particular prism” which we interpret as investigating the relation that exists between the student and their environment; seeking to understand how the student “becomes aware of, interprets, [and] emotionally relates to a certain event” (Vygotsky 1994, p. 341). We propose to extend Azevedo, Martalock and Keser’s article using *perezhivanie* allowing a richness to emerge from the data as this concept encompasses the students’ and teachers’ past experiences, the social relations and the material aspects of the learning environment. On an individual level, the personal characteristics of each student ensure that “different events elicit different emotional experiences [*perezhivaniya*]” (Vygotsky 1994, p. 341).

![Fig. 2](image_url)  
*Fig. 2* Conceptualisation of *perezhivanie* as central to the development of student’s scientific awareness and understanding
Differing levels of awareness and insight means that some students are able to generalise more than others when considering representation in IG. Students react differently when being questioned by the teacher and peers. This is dependent on their past experiences and understanding of the situation and how they are experiencing it emotionally at that moment. In the classroom environment a teacher’s question or questioning style needs to be considered as part of the social and material environment that interacts with the student’s personal characteristics and has the potential to elicit a different perezhivanie in each student. Christine Chin (2006) using Jay Lemke’s (1990) work suggests that a traditional science classroom operates with the teacher asking a closed information seeking question, expecting a short answer that is based on “recall or [at a] lower-order cognitive level” (Chin 2006, p. 1316). The student answering is either praised or corrected (Chin 2006). Troy Sadler (2009) agrees and suggests that teachers are the experts and adds that students work at gaining facts and understanding so they can pass exams. “Students’ practices are often motivated by the perceived need to figure out what the teacher wants them to know” (p. 7). Just as important, but an often overlooked area, is students’ questioning. As Pei-Ling Hsu (2007) states, “when students question, they seek meaning and understanding, construct knowledge and reconceptualize what they already understand in a different way. They in fact are connecting new ideas and linking them to what they already know” (p. 282). The concept of perezhivanie allows us to go beyond the whole class analysis and take into consideration the individual student’s emotional relation to the collective situation. As Vygotsky explains:

An emotional experience (perezhivanie) is a unit where, on the one hand, in an indivisible state, the environment is represented, i.e. that which is being experienced – an emotional experience (perezhivanie) is always related to something which is found outside the person – and on the other hand, what is represented is how I, myself, am experiencing this, i.e., all the personal characteristics and all the environmental characteristics are represented in an emotional experience (perezhivanie)... So, in an emotional experience (perezhivanie) we are always dealing with an indivisible unity of personal characteristics and situational characteristics, which are represented in the emotional experience (perezhivanie). (Vygotsky 1994, p. 341)

When advocating perezhivanie as the unit of analysis, Vygotsky argues that the focus should be on units “which do not lose any of the properties which are characteristic of the whole” (1994, p. 341). We believe that analyzing teacher questioning in isolation does lose some properties characteristic of the whole (the unity of personal and environmental characteristics). Perezhivanie offers a different way of analyzing the data which takes into account individual and collective experience, relations, emotion and personality within the complex social environment of the classroom.

A different perspective on the process of discourse practices

Azevedo, Martalock and Keser propose that by “comparing and contrasting” across different research sites their theoretical program is delineated and the similarities and differences of discourse practices provide a comprehensive representation of the discourse used. Using a cultural historical reading of the proposed study, we advocate a single-case study at one research site (see Roth 2007, for example) and consider each focus participant’s perspective (Hedegaard and Fleer 2008). We argue that this systematic and holistic approach offers a solid foundation for building a general theory.
Differences in our method in comparison to Azevedo, Martalock and Keser begin at the initial stages of the research, in formulating the study design and deciding the type of data to collect, as the theoretical orientation influences approaches to data collection (Hedegaard and Fleer 2008). A cultural–historical orientation would focus on the original small group phases in order to understand the origin of discourse patterns before they are presented in the whole class situation. Azevedo, Martalock and Keser note:

We did record one episode of arguing at UTDP, but it took place among members of a group while they worked on re-designing their representation and discussed their ideas with the teacher—i.e., outside the public, whole-class sphere of discourse that is our analytical focus.

In Avezedo, Martalock and Keser’s article, there are instances during whole class discussions where multiple overlapping points of view and background comments are noted as ‘inaudible’ in the data. It would be consistent with our approach to examine the video recordings for the affective dimension building in these possibly intense segments and for evidence of collective arguing developing across the group; the collective perezhivanie of the group.

A further difference in our approach becomes apparent in the analysis stage. Using a cultural historical method, relational patterns in the video data are analysed and video clips are generated which can then be re-analysed in relation to the central concept(s) arising from the research question (Hedegaard and Fleer 2008). When new insights are gained, the video data is revisited and consulted for evidence. In Azevedo, Martalock and Keser’s article, the orientation informing data transcription is codified according to the conventions adapted from Rogers Hall and Reed Stevens (1995) and analysis of discourse practices proceeds from the transcript (Hsu 2007). Thus thematic analysis in the later stages is influenced by these earlier decisions. The transcription convention presented by Avezedo, Martalock and Keser includes non-verbal factors such as gestures, for example, holding up a representation. We would collect data that includes direction of gaze and the affective dimension that are needed for an analysis in relation to perezhivanie (all non verbal cues and group dynamics and apparent relations). From the video clips we then write “vignettes” which make explicit the researcher’s perspective and what is happening in the social and material environment and the relations from the student’s perspective.

The intensity of social relations is a key factor in the cultural–historical approach. The authors argue against analysing this more “complex” activity sequence as they wish to obtain “quick analytical gains…while avoiding complications” (Azevedo, Martalock and Keser). It is suggested that in the small group settings and through viewing the ‘inaudible’ data there is potential for highlighting the emotional relations, between the students and between the teacher and students. From here we would analyse how the students experience variations of discourse within the context of the classroom situation. We believe that using perezhivanie as the unit of analysis, rather than the “grain size” of “turns-at-talk” (Azevedo, Martalock and Keser) preserves the unity of “environmental and personal features” (Vygotsky 1994, p. 342). Thus we advocate a focus on the origin and the process rather than the resulting classroom discourse; on the small group and individual experience of the students and teacher engaging together in IG design-based activity and on systematically analysing and re-analysing video data, rather than transcripts.
Focusing on the origin and the process

To develop perezhivanie as the unit of analysis, we would interview each participant soon after the data sets were gathered and show the video to the participants, seeking clarification and comments. Rather than “comparing and contrasting” across sites we would follow the same participants over a period of time. This would enable a more in depth examination of the data allowing the students’ perezhivanie to emerge. In particular it would be important to ascertain the students’ attitude to the teacher’s questioning and how this shows the students’ developing scientific awareness. Using perezhivanie as the unit of analysis we would ask what each participant is trying to achieve with their questioning; what does each question mean for the student, how does each student perceive their teacher’s or peer’s intent? For example does the student feel that the questioning is designed to find out what they know, or do they perhaps interpret the question as a personal criticism or recognition of their ability to answer the question? A more in depth examination of questioning has the potential to result in a comprehensive form of analysis from each participant’s perspective and show each student’s developing scientific awareness. Thus perezhivanie provides a solid foundation to build a general theory of science classroom discourse.

Azevedo, Martalock and Keser note that Katherine McNeill and Diane Pimentel (2009) use “dialogicality to ascertain the students’ ability to state their position and the way in which their peers’ positions are addressed”. However, Azevedo, Martalock and Keser analyse the whole class process of design and redesign where “the teacher can have the most impact by orchestrating substantive and productive discursive practice among all participants”. The traditional power positioning of the teacher is evident, where the teacher maintains control of the activity and the line of discourse that follows. Using perezhivanie as the unit of analysis focuses attention away from the teacher’s discursive practices towards other variables. These variables include the whole process of IG, individual and small group interaction within the whole class, the teacher’s personality, the students’ relations with each other and the teacher, the emotional nature of these relations and what effect these have on the environment and each student’s developing scientific awareness.

To use the initial teacher discourse, group conversation and interaction with the teacher, coupled with the background comments enables the analysis of the whole process of development of the students’ emerging scientific awareness (Vygotsky 1987) during the design of IG and not solely the analysis of conversation surrounding the product of IG. We propose that by using the whole process, strength is added to the main rationale behind the article, “To engage students in such discourse practices, therefore, is to provide them with opportunities to participate in core aspects of scientific disciplines” (Azevedo, Martalock and Keser).

Analysing the data using perezhivanie as the unit of analysis

To add substance to our argument we have drawn on the rich data from Azevedo, Martalock and Keser’s article and used perezhivanie as the unit of analysis. In our cultural–historical analysis we have interpreted the data taking into account Azevedo, Martalock and Keser’s goal to uncover the discourse practices characteristic of IG activities stated in their research question “What are the students and teacher doing as a whole and how is this reflected in their talk and action?” We have combined this with the aims of our response to use perezhivanie as the unit of analysis.
Data Set One has been chosen from Benson Middle School (Azevedo, Martalock and Keser’s article). In this example, we have used the teacher and the students Steve and Andrea’s contribution to the whole class conversation for analysis, as this subset incorporates emotions. The information in this data set was relevant to Azevedo, Martalock and Keser’s aims and analysis. By focusing the analysis on day one of the study, the data presented from Benson Middle School is limited to audio recordings and field notes, precluding the possibility of revisiting the video data for non-verbal cues not evident in the field notes and audio. This data set reveals some important possibilities for thematic analysis using perezhivanie.

**Important turns of talk in Azevedo, Martalock and Keser’s Data Set One**

In the first four turns at talk (TT) we see the teacher posing a general question and later answering for Steve. We cannot ascertain if Steve was invited into the conversation by non-verbal gestures (eye contact, movement of participants) but it is noted in the analysis that he lifts his representation at TT4. The teacher and students talk about and for Steve’s representation of IG from TT4 to TT9. TT10 is the first time that Steve enters the discussion. At TT12 Steve re-enters the conversation but is treated in the same manner as Andrea (talked over). TT13 returns to Andrea who suggests that Steve should use something that relates to the picture. In TT14 Steve asks what relates to his representation. By TT17 Andrea has returned to the question a third time discounting Steve’s answer. Finally in TT18 the teacher interjects and asks the whole class for their personal opinion regarding other suggestions.

**Emerging perezhivanie**

Using CA would draw the attention to Andrea and the teacher as they have the most TT and seem to keep the discussion moving. But using perezhivanie highlights Steve’s contribution to the discourse of the classroom; although he had only three TT, they were important.

The audio recording and field notes from the first day of the study are seen as a static representation of data collection, whereas Marilyn Fleer (2008) argues for the use of digital video recording in conjunction with field notes as these offer a dynamic system to which the researcher can return to review the dynamics and the relational patterns of the situation. Azevedo, Martalock and Keser’s transcription is based on the first hour of the design based IG scenario. Hsu notes that “Many studies have their own conventions for transcription” (2007, p. 287) and as in this case, the interpretation of the transcription is left to the reader.

**Individual perezhivanie**

Using a cultural–historical approach we analyse the transcript from Steve’s perspective. We examine Steve’s individual perezhivanie using Data Set One as an example. We note that this episode presented in Azevedo, Martalock and Keser immediately follows a class discussion where the students and teacher became aware of each other’s approach to representing zero velocity and that Steve’s representation shows an incorrect motion pattern. Steve holds up his representation (TT4) and the group are addressing this material aspect (Vygotsky 1994) of their classroom environment. We see that when Steve enters the discussion at TT10, he uses a question “What are you going to use?” He seems disengaged
and shows no ownership of his representation. Steve uses the word “you” when talking about his own design. Here Steve could be experiencing a range of emotions from being quite proud of himself “They like and are talking about my good work” to embarrassed “They are criticising and don’t like my work”. In our post video interviews we would ask Steve about his feelings at this moment and whether or not he understood the task. We would also seek to find out which of Steve’s personal characteristics were pertinent in relation to this situation (Vygotsky 1994). Steve’s reticence to put himself forward could indicate that he is not an outgoing person, or he may feel his scientific understanding does not meet the expectations set within the classroom. He allows others to talk about his design up to TT10 without comment or interjection. From this it is difficult to determine Steve’s social position within the group. We can see from this brief analysis that the complexity of relations between personal and environmental characteristics is intertwined with the affective aspects of individual participants and this is how we interpret Vygotsky’s (1994) use of the concept perezhivanie. Here we have considered the individual perezhivanie of Steve but perezhivanie needs to be considered both as an individual and a collective concept. Next, we consider the collective perezhivanie in the classroom as Andrea re-enters the discussion.

Collective perezhivanie

When considering the collective perezhivanie of the classroom we continue to draw on Data Set One as an example. In TT13 Andrea’s power positioning emerges as she (once again) asks the whole class to wait while she forms an answer. From her answer, we can interpret a possible range of emotions, from empathy as she realises that Steve needs help with his interpretation, to the possibility of acting like a teacher and giving Steve a hint of what to do but not telling him explicitly her meaning (Sadler 2009). It emerges that Andrea may be aware of the teacher’s discourse and has modelled her response on the way the teacher had answered a question that he had posed (TT4). In TT17 Andrea returns to the question a third time and provides a clear indication of emotion in her emphatic use of the word “YOU” addressed at Steve. This analysis provides an example of the collective concept of perezhivanie: The relations between the social environment, material environment and the pertinent personal characteristics of Steve and Andrea are indivisible. The participants are drawn together and are emotionally experiencing the whole class dynamics of the discussion. Azevedo, Martalock and Keser identified a special quality about the data presented in turns 2–18 of this data set, referring to an “identifiable moment in which, as a whole, participants oriented themselves toward a common goal within the larger flow of the activity”. We believe that using perezhivanie as the unit of analysis enables a deep theoretical exposition of this “moment”, “common goal” and “flow of activity” by showing the unity of social, material and personal characteristics entwined with the emotional tensions and intensity in the classroom experience.

Questioning the questions

Using individual and collective perezhivanie enables analysis of how students generalise their scientific awareness (Vygotsky 1987) in relation to IG discourse. We see Steve and Andrea operating differently within the classroom, Steve is quiet and allowing others to talk about his representation until TT10 but then he seems to acknowledge that the class are trying to help him and asks what they would use. In contrast, Andrea is active from the beginning of the transcript and continues to question, in fact posing the same question three
times (TT5, 7, 9). Only being able to analyse from the transcript of Azevedo, Martalock and Keser’s article we offer two hypotheses. Andrea is taking the role of a traditional teacher and is asking a closed information seeking question and expecting a short answer (Chin 2006) or she may be trying to seek meaning by connecting ideas and linking them to her past experience or own IG representation (Hsu 2007). In TT18 the teacher singles out individuals and then asks the whole group and challenges the class that if they don’t “personally like the equal sign” to speak up. Is the teacher showing frustration or trying to extend the discourse? Here we see a personal questioning pedagogy, an emotive style of questioning and the possibility that the teacher recognises that students have different understanding and scientific awareness of the concepts with in IG.

Concluding comments

Azevedo, Martalock and Keser’s informed position makes an important contribution to understanding and forming the initial stages of a general theory in relation to discourse practices and design activity in science classrooms. Our commentary rises to the challenge set by the authors, which is to engage others to contribute to the long-term development of the general theory. Our commentary proposes that a robust theorisation needs to occur prior to formulation of a general theory. Vygotsky’s (1987, 1994) work offers a useful methodology and theorisation of the ideas put forward by Azevedo, Martalock and Keser and provides a different view than is offered by the authors. This theorization advocates for a different analysis of discourse through the use of perezhivanie as the unit of analysis.

Through the use of Vygotsky’s (1994) concept of perezhivanie as the unit of analysis, we make visible the importance of approaching the research question from a theoretical point of view. Through using Azevedo, Martalock and Keser’s data our analysis shows a possible range of emotions that students may feel during participating in a science classroom. The analysis offers different perspectives of participants, specifically the important role that both the teacher and students undertake in building discourse through their common use of statements, questions and interactions in the science classroom. The student’s attitude to questioning and questioning as a meaning making process, rather than questioning style, comes to the fore in our analysis. We suggest that the role of the relational aspects together with the “inner relations between emotion and practical activity” (Roth 2007) in the type of discourse offered by each student needs to be explored further.

We have demonstrated how Vygotsky’s cultural historical theory (1987, 1994), specifically the concept of perezhivanie, can develop Azevedo, Martalock and Keser’s informed position in generating a stronger theoretical basis for an initial general theory in relation to discourse practices and design activity in science classrooms. We agree that this is an important contribution to science classroom development and high school science teaching and learning but an enormous task and will succeed if there is collective work on the project.

Acknowledgments We wish to acknowledge with thanks the help and guidance of Professor Marilyn Fleer and acknowledge the monthly Dialectical Logic Learning Space (DLSS) reading group conversations led expertly by A/Professor Nikolai Veresov, which have been instrumental in guiding our understanding of perezhivanie as a concept.
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Megan Adams is a Teaching Associate and current PhD Candidate at Monash University in the Faculty of Education. Her current research interests are science, pedagogy, cultural historical contexts of early childhood education, children and families experiencing global transitions, home/school pedagogy and gifted children.

Sue March is a researcher and current PhD Candidate in the Faculty of Education, Monash University under the supervision of Professor Marilyn Fleer. Her current research interests include: Child development and early childhood science and technology with a focus on cultural–historical theory.
A cultural historical theoretical perspective of discourse and design in the science classroom

Megan Adams

Abstract Flavio Azevedo, Peggy Martalock and Tugba Keser have initiated an important conversation in science education as they use sociocultural theory to introduce design based scenarios into the science classroom. This response seeks to expand Azevedo, Martalock and Keser’s article *The discourse of design-based science classroom activities* by using a specific perspective within a sociocultural framework. Through using a cultural historical (Vygotsky in *The history and development of higher mental functions*, Plenum Press, New York, 1987) reading of design based activity and discourse in the science classroom, it is proposed that learning should be an integral part of these processes. Therefore, everyday and scientific concepts are explained and expanded in relation to Inventing Graphing and discourse presented in Azevedo, Martalock and Keser’s article. This response reports on the importance of teacher’s being explicit in relation to connecting everyday and scientific concepts alongside design based activity and related science concepts when teaching students. It is argued that explicit teaching of concepts should be instigated prior to analysis of discourse in the science classroom as it is only with experience and understanding these processes that students have the resources to call upon to argue like practicing scientists.

Keywords Everyday and scientific concepts · Discourse · Design based · Sociocultural · Cultural historical theory
To perceive something in a different way means to acquire new potentials for acting with respect to it" (Vygotsky 1987, p. 190)

Flavio Azevedo, Peggy Martalock and Tugba Keser’s use of sociocultural theory to expand design-based pedagogy through Inventing Graphing (IG) in the science classroom is highly significant as it moves away from a constructivist approach. From their informed position, the authors’ situate their research of discourse and activity within a broadly sociocultural framework and draw upon a wide range of theories such as situative learning, conversation analysis and interaction analysis. The authors note in the limitations of their study that “by definition such a theory touches only partly on issues of learning”. This response seeks to expand Azevedo, Martalock and Keser’s article, The discourse of design-based science classroom activities, by using a cultural historical (Vygotsky 1987) reading of learning and concept formation. It is argued that concept formation and learning are an integral part of the science classroom and should be developed prior to analysis of discourse in the science classroom.

Proposing a general theory between activity and discourse

Azevedo, Martalock and Keser from their informed position seek to propose a general theory regarding the relationship between activity types and epistemological discourse practices in the science classroom. The authors use a broadly sociocultural approach to argue for design-based activities within the science classroom. The article draws upon empirical data collected from two schools where whole class discourse is illustrated in conjunction with the design-based activity of Inventing Graphing (IG). IG is a design based activity that involves students representing motion and stopping in pictorial form. Students were invited to share their graph with the whole class and iteratively design a graph with the aid of whole class discussion (describing, explaining and argumentation). “IG seeks to engage students in [these] representational practices while at the same time providing a path for them to articulate more canonical understandings of Cartesian graphs their properties and contexts of use” (Avezedo, Martalock and Keser). The authors analysed the first session of whole class discussion at two sites, through examples from both research sites the type of discourse present in classrooms is explained; that of describing, explaining and arguing.

Returning to original sources

A broad sociocultural framework positions “participation and discourse as reflexively related to knowing and learning (Lave and Wenger 1991)” (Avezedo, Martalock and
Keser). In this response it is argued that the process of students’ conceptual learning, understanding and development in the science classroom should be an integral part of activity and discourse and has the potential to be included in research similar to that of the research conducted by Azevedo, Martalock and Keser. One suggestion is to be specific regarding the type of theoretical perspective used within sociocultural theory. For example, using a cultural historical reading of Azevedo, Martalock and Keser’s research offers a different perspective and includes development and learning as a basic premise in the theory. Lev Vygotsky perceived a psychology that moved away from the traditional separation of behaviour and consciousness. He proposed a nonlinear system of concepts that supported the holistic nature of human development. Vygotsky’s (1987) psychological theory was one of understanding social and mental activity and its organisation through historical, culturally constructed artefacts. Cultural historical theory values the holistic nature of human development and the importance of the human mind being mediated through the use of tools, activity and signs. Using a broad sociocultural theory as Azevedo, Martalock and Keser do, provokes challenges as it separates activity, discourse and learning which are dialectically related within this theory. It is suggested that returning to the original source and being explicit about the perspective of sociocultural theory used is important when constructing a general theory of discourse in relation to the science classroom as proposed by Azevedo, Martalock and Keser.

Azevedo, Martalock and Keser’s cite many sociocultural theorists such as June Lave and Etienne Wenger (1991) and Barbara Rogoff (1995) and James Gee (1991, 2004). The authors include Charles Goodwin and Marjorie Goodwin (1998) cited from a text edited by Yroj Engestrom and David Middleton (2006), these authors use Activity Theory (AT), the references are secondary sources which build upon the original theories of Vygotsky (1987), Aleksi Leontiev (1978) and colleagues (for a discussion of the differences between Leontiev and Vygotsky see Kozulin 1989; a further expansion is the difference between Leontiev and Engestrom see Kaptelinin 2005). While secondary sources build and expand on original theories and provide different perspectives, returning to the original source orients the author and reader with a stronger understanding of the original concepts and threads of the argument used. Azevedo, Martalock and Keser use secondary sources within a broad sociocultural and AT perspective in conjunction with other theories. This broad based framework offers a challenging proposition for new knowledge to emerge. It is argued that there is scope for more to be learned and new ideas to emerge when primary sources or new theories are proposed and explicitly drawn upon (see for example Marilyn Fleer 2011).

Wolff Michael Roth states “theorizing within a sociocultural framework has often not achieved the degree of generative power that is potentially inherent” (2012, p. 256). Azevedo, Martalock and Keser’s theoretical discussion describes and justifies their broadly sociocultural choice. The authors, informed position enables them to call on a wide expanse of theories that overlap with a sociocultural approach, such as situative frames of learning, conversation analysis and interaction analysis and hint at beginning theorization. For example, when describing the relation between activity and discourse it is stated, “we seek to jumpstart a sizeable theoretical program that foregrounds some yet-unexplored facets of the relationship between science classroom activities and discourse” (Azevedo, Martalock and Keser). The authors introduce different forms of activity found in the science literature in conjunction with discourse such as co-construction of learning and teachers allocating turns within the classroom. There is the potential for the authors to take this further theoretically. To situate activity within a theory is important as it aids the reader’s focus and understanding but most importantly as with the historical literature
cleverly drawn upon in Azevedo, Martalock and Keser’s article, original theories position the argument and provide a link from the past to the present, forming the potential for new knowledge to emerge from a general theory which the authors propose. An example of this is Roth (2012) when discussing a dialectical reflexive approach to learning in the science classroom. Roth (2012) categorises activity from a Cultural Historical Activity Theory perspective where activity is understood as:

a societal formation that has historically arisen through division of labor and serves to meet a collective (i.e., generalized individual) need—rather than …… being busy, vital movement. (2012, p. 260)

Roth (2012) then uses this theorization of activity throughout the article to build his argument regarding a dialectical, reflexive approach to learning science across settings. Situating a discussion of activity across a broad sociocultural foundation with overlapping theories is challenging, as there are common areas in such theories, which is noted in Azevedo, Martalock and Keser’s article but also differences. An example of difference within the one theory is offered by Alex Kozulin (1986) who proposes that there are fundamental differences between Vygotsky (1987) and Leontiev’s (1976) theories of activity. In much of the literature Leontiev (1978) is cited as working with Vygotsky and extending his theory, Kozulin (1986) disputes this claim and suggests fundamental difference in the two approaches:

Vygotsky’s theory views higher mental functions as a subject of study, semiotic systems as mediators and activity as an explanatory principle. In A. N. Leontiev’s theory, activity, now as activity, and now as action, plays all roles from subject to explanatory principle. (p. 273)

Therefore, returning to the original source, situating activity within a theory and being specific about the perspective within sociocultural theory would aid expansion of new knowledge and help to position theoretically the author’s idea of a general theory robustly.

**Linking teaching, learning and the design process**

While it is understood that Azevedo, Martalock and Keser are working on a general theory of discourse in the science classroom and the authors offer a design based scenario termed Inventing Graphing (IG) to instigate whole class discussion. A different perspective may offer more information regarding the process of learning that students move through in preparation for the activity. Azevedo, Martalock and Keser used two sites in their research. At the first site, IG was instigated in a trial with eight sixth grade students as an “extension to the students’ school activities. Initially activity was meant to serve as a prelude to an in depth treatment of Cartesian graphing” (Azevedo, Martalock and Keser). There were five 50 min sessions. At the second site, grades seven to 11 were represented by nine students, the “goal was to introduce students to key scientific ideas through the design and use of representational forms across disciplines and domains” (Azevedo, Martalock and Keser). There were three 70 min sessions. Analysis focused on the first session of activity at both sites.

To position the research within a cultural historical theory, it is important to know the type of prior learning students were afforded in conjunction with the explicit teaching of science concepts that the students received prior to implementing the task of IG. Another
important understanding is that students need a link between the design based concepts and the science concepts embedded within the design process.

It is argued that these are important processes of learning that need to be considered when making a general theory of discourse. The foundations and understanding that students hold may determine the type of discussion undertaken in the science classroom. The following discussion expands these areas in relation to Vygotsky’s (1987) cultural historical theory.

Prior learning and science concepts behind IG

Recently, Vygotsky’s theory has been used to investigate student’s conceptual development in schools (Hedegaard and Chaiklin 2005). One important area of Vygotsky’s theory is that instruction and learning in schools should further student development in regard to advancing concept formation (Hedegaard and Chaiklin 2005). This important and integral part of cultural historical theory has the potential to be expanded in Azevedo, Martalock and Keser’s article and will be discussed in this section.

The research on seven to 15 year old students’ understanding of scientific concepts shows that these students’ have a variety of opinions regarding the concepts that are taught in schools (Fleer and Robbins 2003). It is understood that the personal views and understanding held by individual students’ influences their interpretation of the scientific experiences and concepts that teachers offer (Roth 2000). Therefore, it is important that teachers have an understanding of the learning challenges that students perceive and the concepts that students hold prior to beginning a unit of work (Skamp, Boyes and Stanisstreet 2004). Apedoe and Schunn (2013) explored students use of problem solving strategies while solving a prototypical design task in relation to learning science concepts and extend this argument by suggesting that “Understanding the ideas and strategies that students bring with them to the classroom environment has important implications for the design of curricula and classroom instructional practices” (2013, p. 776). It is argued that these variables could affect the discourse of the whole class as Roth (2012) in research regarding graphing competencies found that eighth-grade students who completed the process of investigation and experienced data collection, analysis and presentation of their work were able to outperform older people at the same task. Roth deduced that the students “familiarity with the process allowed them to outcompete the older and more schooled preservice teachers with at least one [university] degree” (2012, p. 272). Therefore, the experience a student can draw upon from the design process during whole class discourse described in Azevedo, Martalock and Keser’s article may determine the type and quality of discourse in science classrooms, such as explaining, describing and arguing that students participate in during the presentation of their IG. Would the first session of IG afford students enough time to gain familiarity with all of the processes involved in IG?

Vygotsky (1987) noted the importance of instruction to advance the process of student concept formation and consequent development. He argued that students are provided with an everyday understanding of concepts from their life experiences and when combined with instruction regarding academic concepts, the student is afforded the potential to build a strong conceptual basis and understanding. It is argued that if students are afforded the opportunity and are provided with instruction to develop a strong conceptual base, students would be better equipped to argue for or against a proposition during science classroom discourse, rather than relying on “teachers’ questioning strategies and pedagogical moves worked to shape different patterns of students’ discourse” (Azevedo, Martalock and Keser).
As Katherine McNeill and Diane Pimental (2009) state “nonscientists were more likely to draw from personal anecdotal experiences whereas scientists were more likely to question how the data were collected and analysed when evaluating claims” (p. 226). Scientists learn how to ‘evaluate claims’ through a process of training and experience over time, students need instruction and experience to be able to participate in this type of discussion. It is for this reason that an understanding of concepts using Vygotsky’s (1987) theory is explored including an explanation of how students move from using their personal experiences to understanding concepts in science. Reference to Azevedo, Martalock and Keser’s article will be made throughout the discussion.

Concepts and moving from everyday to scientific concept formation

Understanding the term ‘concept’ by using a cultural historical reading requires dialectical logic. Vygosky (1987) discusses a concept not as a static entity but a developing, dynamic process that is continually evolving. Vygotsky argues “At any stage of its development, the concept is an act of generalization. The most important finding of all research in this field is that the concept—represented psychologically as word meaning—develops” (1987, p. 169–170). The word ‘develops’ is key in the above quote as it describes the process of development of concepts as they are occurring, making concept formation dynamic. This argument is highlighted further when Vygotsky proposes, “We know that the concept is not an automatic mental habit but a complex and true act of thinking that cannot be mastered through simple memorization” (Vygotsky 1987, p. 169). Such a perspective is important for Azevedo, Martalock and Keser’s argument supporting design based activities in the science classroom. Design based activities “engage students as active participants” and “support reflection and discussion” (Azevedo, Martalock and Keser). The authors’ proposal to use design based IG sets the potential foundation for students to learn concepts through the use of “multiple strategies and solutions” (Azevedo, Martalock and Keser). This fits neatly with Vygotsky’s cultural historical theory as concept development is about the process. IG design consolidates a dynamic, iterative process, that of “defining, creating, assessing and redesigning an artefact” (Azevedo, Martalock and Keser) in conjunction with explaining, describing and argumentation. Using IG as a pedagogical tool is a move away from memorization of knowledge and has a focus on the process rather than the product. Teacher instruction is important when introducing concept development (Vygotsky 1987) and understanding the design process (Apedoe and Schunn 2013).

Vygotsky (1987) explains concept formation through two spiralling lines of development: spontaneous concept formation (everyday concepts) and non-spontaneous concept formation (scientific or academic concepts). According to Vygotsky (1987) children experience spontaneous concepts through their everyday life with real experiences. On careful examination of the extensive literature associated with Azevedo, Martalock and Keser’s article it was found that the ‘desert motion scenario’ and context (Benison Middle School) had been used and discussed in more detail by Bruce Sherin (2000). The author discussed how students learn to use scientific and mathematical representations. More information was provided of the situation at Benson Middle School. Sherin’s (2000) article describes students using a form of software called Boxer programming as part of a Physics program, where a “turtle is made to move around the computer screen in a manner that replicates the motion of some physical object” (2000, p. 410). The computer simulations of movement provided a starting point for the desert motion scenario at Benson Middle school (Sherin 2000). According to Vygotsky (1987) everyday concepts of movement form...
in the student’s daily life through stopping and starting while in a car or riding on a bicycle, for example. It is suggested that the students had been made aware of using and representing motion on a computer screen however, there was no reference to an explicit link between the student’s everyday concept awareness of motion and the concept of inertia, or motion that was being represented through the Boxer programme.

The “desert motion scenario” data offered to students in Azevedo, Martalock and Keser’s article originates from Sherin’s (2000) article. This scenario is described as “A motorist is speeding across the desert and she’s very thirsty. When she sees a cactus, she stops short to get a drink from it. Then she gets back in her car and drives slowly away” (Sherin 2000, p. 409). This example is used in Azevedo, Martalock and Keser’s article when students are asked to represent the motion in the scenario through pictorial form.

Vygotsky argues that as development of everyday concepts occurs “the [student] does not have the capacity to operate abstractly with the concept” (1987, p. 219). The student can interact with the object that the developing concept represents but does not have a conscious awareness of the concept and if questioned may find it difficult to explain. Drawing on Azevedo, Martalock and Keser’s rich data there is evidence that some students may not have conscious awareness of the concepts underlying their representational forms for example, in Transcript 1, Andrea questions Steve’s use of an equals sign representing the length of time the driver stopped at the cactus (5. Well you wouldn’t look at it and go … Oh, the equal sign means he stopped). Andrea asks two follow up questions (7. Why is it an equals sign?; 9. Well, why though?). Steve does not justify or explain why he used the equals sign to represent the time of the stop, he returns the question to Andrea (10. What else are you going to use?). Andrea does not follow up her question but answers by suggesting the possibility of linking a representation that relates to the design that Steve created. Steve’s response shows little understanding of what his representation means (14. What relates to this?). It is from this Transcript that Vygotsky’s theory is highlighted, Steve seems to find it challenging to relate abstractly with the pictorial representation.

Vygotsky (1987) argued that there is a dialectic relationship between everyday and scientific concepts. When there is a direct connection between the two concept formations, the student is able to form meaningful understanding embedded in everyday situations and can apply the newly forming concepts to both concrete and abstract situations. Vygotsky (1987) argued that understanding everyday concepts are important, as they lay “conceptual pathways for instruction” (Fleer 2008, p. 783). However, for this to occur the students’ need instruction to aid understanding of the scientific concept (Vygotsky 1987).

Scientific concepts according to Vygotsky (1987) develop through formal instruction. Through instruction, students obtain conscious awareness of the abstract concept and “easily defines the concept, applies it in various logical operations, and identifies its relationships to other concepts” (Vygotsky 1987, p. 218). To extend the desert motion example from IG in Azevedo, Martalock and Keser’s article, the students have experienced representing motion in the classroom through using the Boxer programme and then pencil and paper representations of graphing motion. One strategy for taking the scientific concept further would be for the teacher to introduce motion or inertia and then help the students to link their everyday experiences with the scientific concepts through Cartesian graphing with a Distance Time graph or Velocity Time graph, for example. As with Roth’s (2012) example, when eighth grade students experienced the process of investigation and experienced data collection, analysis and were able to present their work through whole class critical discussions they showed greater understanding than people with university degrees. The students in Azevedo, Martalock and Keser’s article may be able to use these concepts of Cartesian graphing through experiencing the process in the same way as Roth’s (2012).
participants did and then applying the understanding to other related motion concepts such as plotting the parabola of a ball for example.

The important understanding here is that the student is experiencing and learning within a specific context, the everyday experience of representing motion in conjunction with the scientific concept formation of plotting a real Cartesian graph, where the teacher explains to students how the process works, with examples which are meaningful to the student’s contextual situation. “Juxtaposing everyday and scientific views in the classroom can support students engaging in the different discourses and making sense of how the different ideas fit together” (McNeill and Pimental 2009, p. 226). Vygotsky’s (1987) theory of everyday and scientific concepts takes this further and argues for the importance of the dialectic relationship between the two types of concepts. Understanding connections between everyday and scientific concepts takes time for the teacher to explain and for the students to experience relevant forms so that the link between the everyday concept and the scientific concept is understood. Mariane Hedegaard argues that “in a teaching situation, the goal is both to provide a [student] with knowledge of the subject area and skills concerned and also to motivate the [student] to set himself goals that involve an acquisition of knowledge, skills and motives linked to the subject being taught” (2002, p. 62). Therefore, it is important that the students have an understanding of the concepts the teacher wants to introduce prior to argumentation skills being used.

**Linking science concepts and the design process**

Apedoe and Schunn (2013) propose that students learn important design principles through experiencing the process of building and testing in design based activities but students do not form links between the design concepts and the science concepts as the activities are not structured to meet this demand. Teachers need to be conscious of what students know (Apedoe and Schunn 2013) and provide explicit connections for students through instruction and contextual experiences (Vygotsky 1987). This is important for the process of aiding developing everyday and scientific concepts in students and for students to make connections between science concepts and the design process. It is argued that when students make a connection between everyday and scientific concepts alongside the concepts embedded within a design based instruction through iterations of design, their argumentation and discourse has the potential to be based on strong conceptual knowledge linked to their everyday experiences.

Azevedo, Martalock and Keser’s article highlights the “relationships between students’ and teachers’ discourse patterns” which are discussed in close association with regard to McNeill and Pimentel’s (2009) “prototypical instance of scientific argumentation activity structures”. In both articles, during a whole class discussion, students argue a case for or against a claim towards ‘competing theoretical interpretations of a phenomena’, using evidence to support their theoretical position. The role of the teacher is to use ‘guiding moves’ that do not alter the argumentation between the students but sustain the flow of the argument. This type of argumentation is based on the premise that ‘scientists discuss and defend theories and/or attempt to displace competing viewpoints’ (Azevedo, Martalock and Keser). Arguing is an important skill to have in the science classroom. However, the aforementioned scientists already understand the underlying concepts and have experienced the process of arguing in the science context. For students, the concepts and the process of making connections between everyday and scientific concept formation and the
link between the design process and the science concepts should be part of explicit teacher instruction and students’ experiencing the processes involved prior to the skill of arguing.

**Conclusion**

The aim of this response was to provide a different perspective regarding the article by Azevedo, Martalock and Keser’s *The discourse of design-based science classroom activities*. The authors’ article was framed from a broad sociocultural perspective positioning IG within a new theoretical foundation, from their informed position, the authors were able to use different overlapping theories and expand this work using IG. From a cultural historical reading of design based science classrooms it was suggested that to form a general theory within the science classroom, returning to an original source and using one theoretical perspective positions the process of learning and development into a general theory of activity and discourse through the dialectically related everyday and scientific concepts. The process of student learning and development should be an integral part of the science classroom; it is important for teachers to understand the concepts that students hold prior to beginning a new unit of work (Apedoe and Schunn 2013) and to be explicit when linking everyday and scientific concepts so that students get to experience the processes involved (Vygotsky 1987). Apedoe and Schunn (2013) argue for teachers to link the design based activity to the scientific principles for greater understanding of the concepts involved. It is through gaining experience and understanding the processes involved (Roth 2012) that students may be in a position to argue like a scientist during classroom discussion. Therefore, positioning students to develop skills for argumentation and everyday and scientific concepts is an extremely important part of the development of a general theory of discourse within the science classroom. The importance of Azevedo, Martalock and Keser’s article lies within the sociocultural theory used and the expansion of design based pedagogy into the science classroom. This is highly significant and inspiring work, more theoretical work in science education is needed from this perspective as it is a move away from a constructivist framework.

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**References**


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Megan Adams is a Teaching Associate, Research Assistant and current Ph.D. Candidate at Monash University in the Faculty of Education. Her current research interests are science, pedagogy, cultural historical contexts of early childhood education, children and families experiencing international transitions, home/school pedagogy and gifted children.
Signs of taste for science: a methodology for studying the constitution of interest in the science classroom

P. Anderhag · P.-O. Wickman · K. M. Hamza

Abstract In this paper we present a methodological approach for analyzing the transformation of interest in science through classroom talk and action. To this end, we use the construct of taste for science as a social and communicative operationalization, or proxy, to the more psychologically oriented construct of interest. To gain a taste for science as part of school science activities means developing habits of performing and valuing certain distinctions about ways to talk, act and be that are jointly construed as belonging in the school science classroom. In this view, to learn science is not only about learning the curriculum content, but also about learning a normative and aesthetic content in terms of habits of distinguishing and valuing. The approach thus complements previous studies on students’ interest in science, by making it possible to analyze how taste for science is constituted, moment-by-moment, through talk and action in the science classroom. In developing the method, we supplement theoretical constructs coming from pragmatism and Pierre Bourdieu with empirical data from a lower secondary science classroom. The application of the method to this classroom demonstrates the potential that the approach has for analyzing how conceptual, normative, and aesthetic distinctions within the science classroom interact in the constitution of taste for, and thereby potentially also in the development of interest in science among students.

Keywords Interest · Taste · Aesthetics · Science education · Situated learning · Norms · Values · Methodology

P. Anderhag (✉) · P.-O. Wickman · K. M. Hamza
Department of Mathematics and Science Education, Stockholm University, 106 91 Stockholm, Sweden
e-mail: per.anderhag@mnd.su.se

P.-O. Wickman
e-mail: per-olof.wickman@mnd.su.se

K. M. Hamza
e-mail: karim.hamza@mnd.su.se

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The backdrop for this paper is the large body of knowledge on students’ interest in science. Because most of this knowledge is based on reports from students about their experiences of science and science education (Osborne, Simon and Collins 2003), using psychologically oriented constructs and methodologies (Krapp and Prenzel 2011), there is a need to study also more directly how interest in science is constituted through classroom interactions. The aim of this article is to develop such a methodology. To reach this aim we use the concept of taste as an operational proxy for the more psychologically oriented term interest. As will be demonstrated in the paper, having taste does not designate merely an affective state of mind, but covers also cognition, values, and norms—aspects recognized to be of great importance for peoples’ possibility to engage in social practices (regarding science education, see e.g. Carlone, Haun-Frank and Webb 2011). A taste for classical music, for example, is not simply an emotional state, but results from continuously learning cognitively, aesthetically, as well as normatively as part of social settings. Hence, for instance having a taste for classical music does not mean merely reporting that you enjoy classical music, but entails that you can engage and take part in classical music communications by making certain distinctions through talk and action. Here we adopt such a socially situated approach to develop a methodology to analyze the constitution of taste within the field of science education.

Our approach is based on a combination of pragmatically oriented research on aesthetics and taste in science education (Wickman 2006) and Pierre Bourdieus work on taste in
different fields of French society. Although Bourdieu (e.g. 1984) demonstrated that taste is constituted through people’s upbringings and education, it is not a static condition but something which is constantly transacted as part of situated activity. Since people’s taste becomes visible from what they say and what they do, taste can be observed in action. In this way the concept makes it possible to study how the teaching and learning of the conceptual content of science and the learning of its norms and values are made continuous. Since learning science is at once a social, cognitive, aesthetic, and normative enterprise (Wickman 2006), Bourdieu’s findings regarding taste should be relevant for the enterprise of moving the study of the development of interest in science in closer contact with the moment-to-moment interactions within the science classroom. Taken together, the methodology that we present makes it possible to empirically examine the consequences of various types of classroom interactions for the development of taste for science, thereby contributing to the field of students’ interest in science.

The concept of interest

Interest in science has been extensively studied by the science education research community (Bybee and McCrae 2011). The background for a majority of the studies is the reported decline in students’ interest in science in Western countries, whether seen through specifically designed questionnaires or through students’ post-compulsory career choices. Research has also been motivated by the importance that attitudinal factors may have for cognition and, therefore, for learning science (Drechsel, Carstensen and Prenzel 2011). The findings point to a long list of various factors significant for student interest, as for instance gender, school context, age, personality of the teacher, type of instruction, socio-economic background, and student counselling (Tytler, Osborne, Williams, Tytler and Cripps Clark 2008).

In these studies it is not always apparent what kind of interest the findings actually refer to, which is a recognized dilemma in the field (Osborne, Simon and Collins 2003). This ambiguity can in part be explained by different methodological approaches, but also by the vague operational meaning of interest (Blalock, Lichtenstein, Owen, Pruski, Marshall & Toepperwein 2008). In some studies interest is one of many internal entities affecting motivation, whereas in others, interest is equivalent to motivation or other attitudinal concepts (Krapp and Prenzel 2011). Furthermore, interest can be intrinsic or extrinsic, individual or situational, and domain or subject specific (Koballa and Glynn 2007). Finally, interest is usually conceptualized as caused by affective and cognitive factors (Hidi, Renninger and Krapp 2004) and, thus, primarily studied as mental and personal rather than embodied and socially shared.

At the same time, several studies show that interest in science not only refers to attitudes to the conceptual content, but also to the scientific norms and values as they are projected through its practice in the science classroom (Taconis and Kessels 2009). Leif Östman (1994, 1998) argued that apart from the intended curriculum content, there are always so-called companion meanings to be learnt, which convey moral lessons about the relationship between the student and science, as for example: Do I belong here? or Is science for me? Hence, students never learn only the science content, but at the same time also how to articulate and relate to the norms and values of the practice (Jakobson and Wickman 2008), that is, to participate by talking and acting science (Lemke 1990). We therefore argue that cognitive, normative, and aesthetic distinctions have to be examined alongside each other when studying the constitution of interest in science.

In their review on research on interest in science, Krapp and Prenzel (2011) show that the interactions that is taking place between students and between teacher and students may
have significant consequences for the constitution of interest in science. The findings are however primarily based on interviews, questionnaires or rating scales (Krapp and Prenzel 2011). As a consequence, we know little about the situated constitution of interest (Abrahams 2009). There is thus a need to develop methodologies to study the constitution of interest in situ through teaching and learning (Abrahams 2009). Only by using such methods is it possible to examine how teaching can make a difference for students’ interest in science which, of course, is of central concern to science education. Indeed, methods that make us better equipped to understand how the actual classroom transactions influence students’ interest should be helpful to science teachers. Developing such methodologies, however, demands a more action-oriented concept than interest to make it possible for researchers and teachers to observe this constitution in the classroom. In this paper we argue that taste can be used for such a purpose.

The concept of taste

Bourdieu (1984) demonstrated that taste, which is learnt and embodied through upbringing and education, is associated with different social groupings and settings. Being socially situated, aesthetic and normative judgments on phenomena such as politics, art, music, sports, or food-dishes are of great importance when participants in various social groups distinguish themselves in relation to other groups. Taste may thus affect the extent to which people are successful in, and also are given access to, different practices. In academic settings, for example, the autodidact is usually not recognized as an equal just because he distinguishes himself as an autodidact (Bourdieu 1984). In the academic practice you not only learn a content, but also what actions and phenomena this environment recognizes as interesting or not, good and bad, nice and ugly, and so forth (Bourdieu 1984). The science classroom has been described as a specific practice with certain values and norms (Aikenhead 1996) and also here numerous unquestioned distinctions are made about what is good or bad practice (Wickman 2006). Students are often reported to describe this normative practice in stereotypic and negative aesthetic terms: the right explanation dominates science practice, science is for the smart kids, science is a male practice, and so on (Brickhouse, Lowery and Schultz 2000).

Considering that the culture of school science involves normative expectations that often seem to conflict with the values of students, it has been argued that many students may experience the science classroom culture too alien to engage in (Taconis and Kessels 2009). This is supported by the finding that cultural background, such as social class and gender, influences the extent to which students take up a scientific career (Adamuti-Trache and Andres 2008). At the same time, there are indeed schools which succeed in countering the cultural background of their students, in that a larger proportion of students than expected choose a post-compulsory science career (Anderhag, Emanuelsson, Wickman and Hamza 2013). This suggests that we need to look into classrooms more closely.

It is likely that in order to develop a taste for science, students need to learn what distinguishes it, how its distinctions are made, how you are distinguished by others in its activities, and whether you are able to, want, or even like to take part in it. This means meeting the science content of the classroom, not only in terms of concepts as representations, but also in terms of inclusions and exclusions of objects and actions, as well as the normative and aesthetic judgments used in making these distinctions (Wickman 2006). Consequently, to acquire a taste for science does not only mean that you learn to enjoy science but also that you develop a familiarity with, and competence in, how distinctions are valued in this practice in
terms of talking, acting, and being. In a more general societal context than science education, Bourdieu (1984) described this development of taste as transformation of a person’s habitus. The habitus is a person’s learnt and embodied habitual ways of acting. These dispositions, which are a result of upbringing and education (in their broadest sense), have consequences for the person’s potential to participate in different activities. According to Bourdieu (1984) your taste, which is an important part of your habitus, is how you make distinctions. The distinctions you make in relation to practices involving politics, food, movies, literature, sports, science, and so on are what make up this taste. Thus, taste becomes visible through our distinctions, which are the choices of actions and the judgments we make in dealing with people and things as part of practices. At the same time, other people are judging us according to the distinctions we make.

All through his book Distinction, Bourdieu (1984) repeatedly emphasized that his empirical findings on taste should not be seen as static, but as continuously relational, varying and changing through space and time. But although Bourdieu theoretically acknowledged the continuous constitution of taste, empirically he studied taste as an already constituted structural component of society rather than its actual constitution in situ. However, recent developments of Bourdieu’s thinking call for an extension of his structuralist oriented empirical work by studying also how habitus is actually transacted as practice (Albright and Luke 2008). For this reason we supplement his findings with pragmatist theories and methods for studying meaning-making as situated (Wickman and Östman 2002). Indeed, as acknowledged by Bourdieu himself there is a close relationship between John Dewey’s concept of habit and Bourdieu’s concept of habitus (Bourdieu and Wacquant 1992). In both frameworks the two concepts are used as embodied operationalizations for dispositions of action (cf. Bourdieu 1998; Dewey 1922). According to Dewey, people develop certain tastes by taking part in already existing human institutions and customs (e.g. Dewey 1929/1984). Distinctions of taste are not necessarily actions made intentionally, neither are they arbitrary. Rather, they are the ways people can be seen to act. Taste is a set of habits resulting from lived experience and, therefore, should be understood as something that can be seen when transformed in use. In this way taste is continually transacted and at stake and, so, visible for inspection. This is also the operational definition of taste that is used in this paper.

Any methodology needs to be grounded not only theoretically but also in empirical data (Glaser and Strauss 1967). The analytic framework that we develop in this paper is therefore applied to conversations recorded in a secondary science classroom. The purpose is to illustrate how the framework may help in the description and analysis of the constitution of taste in the conversations and activities of science education.

The study setting

Since our aim is to develop a methodology for studying the constitution of taste in classroom settings, we needed to find a school where positive instances of this could be found and where the teaching and not only the students’ socio-economic background contributed to their development of taste for science. For this reason we used statistics from the Swedish National Agency for Education and Statistics to locate a suitable lower secondary school (grades 7–9). We actively searched for a school (a) where a comparatively high proportion of the students recurrently apply for the Natural Science Program in upper secondary school, and (b) where the student population of the school has a heterogeneous socio-economic background. The school chosen qualified in both these
respects. Over a 2-year period 25% of the students of this school applied for the natural science program, as compared to the national mean of 15% for the same period. In Sweden the students choose upper-secondary programs during the ninth grade. The Natural Science Program is the upper-secondary school program with a natural science profile and is preparatory for tertiary academic studies.

Educational career choices and/or subject enrolment sometimes are used as signs of interest in science (Osborne et al. 2003). At the same time, studies have shown that variables such as socio-economic background and educational level of the parents are important for selecting the natural science program in Sweden (Anderhag et al. 2013) as is the case in many other countries (The Royal Society 2008). In schools with children from affluent socio-economic backgrounds and with well-educated parents it is likely that it is the home, rather than the school, that influences the students’ choice. Therefore we cannot assume that a high application frequency to post-compulsory science programs automatically means that this particular school cultivates a student interest in science. On the contrary, application frequency above mean could actually be less than expected considering the socio-economic setup of the student population of the school (Anderhag, et al. 2013). However, in the school of this study, variables correlating to cultural capital gained from upbringing at home cannot explain the high proportion of students choosing the natural science program. For example, although being a complex parameter, during the sample period 29% of the students had immigrant background which is higher than the national mean during the same period of 18%. Parental educational level is clearly associated with the choice of the NSP (Anderhag et al. 2013), and during the sample period, 50% of the students at the school had parents with tertiary education. This is slightly less compared to the national mean of 51%. Since the socio-economic status of the studied students are about average or even somewhat less than average, and since a proportion well above average chose the NSP, it appears likely that the teaching in this specific school play at least some role in this school’s high recruitment rate. Notwithstanding that this deviation is interesting in its own right, our intention was not to make any closer examination into why the students choose post-compulsory science to the extent they do. Nor was our intention to draw any general conclusions regarding the teaching in science in this classroom. As mention above, the reason for that we ultimately decided to make our study at this school was because here we were likely to find relevant classroom data that could illustrate the theoretical constructs. Hence, this school was chosen, because we expected to see positive instances of a taste for science being constituted. A class where students systematically turn away from science education activities would be of little help for our aim. We also decided to choose a lower secondary science class, because this is the age when students are reported generally to “lose” their interest in science (e.g. Tytler et al. 2008), and which thus is an age-group that should be of great interest for future studies within this area. The data for this study comes from a seventh-grade physics class (students about 13 years old). The school is a public K–9 school located in a suburb to Stockholm. In this school there are three science teachers for grades 7–9, one in each of the subjects biology, chemistry, and physics.

The class, with the home background composition discussed above and with an even mix of boys and girls, was filmed and audio recorded during one physics lesson. One camera followed the experienced female teacher as she visited and interacted with the different lab groups. The recordings were transcribed verbatim and analyzed for situations where students actively made distinctions (see below). The excerpts presented in the paper are illustrative representations of the taste constructs found in the material. The video data served as analytical cues clarifying non-verbal interactions such as actions, gestures, and
expressions. This data thus assisted us in the interpretation of aesthetic judgments; occasionally it was for example necessary to review the filmed material to determine whether an utterance was a joke or an ironic remark. The video material was also used to interpret students’ emotions and feelings when making aesthetic judgments.

Even if this is not a study of this classroom as such, some details of the classroom setting are necessary to present in order to understand how the methodology can be used to analyze data. The lesson was chosen because the students had ample opportunities to interact in speech and with materials. The aim of the lesson was to introduce, and for the students to use, formulas and methods to measure the volume of different objects. This activity was part of a unit in which different aspects of matter (e.g. being measurable), was treated. The project spanned over seven lessons and the activity observed was the second of three lessons focusing on volume. Figure 1 (based on Kelly and Chen 1999) describes how this lesson was situated in relation to the other lessons, projects and science units of the academic year.

During the introduction of the activity the teacher clarified for the students that during this lesson they were going to collaboratively measure the volume of different objects, and; the objects measured should be named according to their characteristics (e.g. the small and the big weight). Through her verbal and written introduction the teacher carefully, step by step, described what students were supposed to do and find out during the lab. Besides the practical aspects of measuring objects, she also stressed how this assignment should be carried out, which is illustrated through the following excerpt:

1. Teacher: Are you ready? Can we start? There are a lot of things that I’ve drawn on the board today. Explanations on the things you’re supposed to use. Last week you did a lab on electricity. Tested which material that conducted electricity and which did not and you did a really great job. Today there’re different materials on the desk. And what I especially look at is how you collaborate. If you talk to each other when you do the things, so that there’s not only one person who does all the stuff, but that you jointly help each other so there will be good results. Now you’re going to measure the matter that is on the table. What kind of matter do we have on the desk? Last time we talked a little about matter. Susanne?

2. Susanne: Wood
3. Teacher: Wood is lying on the table, yes precisely. What else are there?
4. Peter: Weights
5. Teacher: There are also weights on the table. What material are they made of?
6. Peter: Like some kind of iron
7. Teacher: Some kind of iron. Like some kind of metal.

During the introduction and also during the practical part of the lesson, the teacher recurrently made distinctions with reference to collaboration and naming. Besides telling the students that she would pay special attention to whether they helped each other, collaboration was also judged as something that was leading to good results. In this activity collaboration was thus distinguished as the preferred way of doing lab work and during the practical the teacher often returned to this aspect of doing inquiry. The students, who clearly enjoyed the activity, worked in groups of three measuring the volume of cylinder-shaped metal weights and cubes of wood. They used beakers and graduated cylinders to measure the change in water volume, when they lowered the weights into them. During the lesson the students jointly had to make sense of a diversity of issues in order to be able to carry out the assignment: they needed to find suitable names for the objects they were about to study, decide on which glassware to use, calibrate and understand the scale on the
Developing the methodology

The aim of this paper is to present a methodology for studying the constitution of taste in science classrooms. Clearly, acquiring taste for science amounts to a continuous and social process where cognitive, aesthetic and normative aspects of participating in science practices become embodied as habits. Viewed in this way, the development of taste for science is understood as the potential consequence of an inclusive and gradual process in which the student learns how actions, words and ways-to-be are distinguished as parts of a practice. However, we contend that irrespective of the actual time required for any observable transformation of students’ habits, and along with that also the possible transformation of their taste, this transformation still takes place in the moment-to-moment interactions between students and between teacher and students. A method for studying the constitution of taste, therefore, needs to begin in these interactions in order not to overlook possibly important steps in the process. Nevertheless, as we present the methodology, we also tentatively outline how the analytical constructs could possibly relate to the more long term perspective in which the development of taste may be realized. Although these outlines are based on how taste was constituted in the science practice studied, they are not to be read as final statements on how taste develops in this specific classroom. Note that the order in which the steps are first presented to the reader is different from their order in the formal method for conducting a “taste analysis” that we eventually suggest. We do this

![Diagram](image-url)
because we judge that the logic of having the steps presented to the reader for the first time is different from how these steps are best ordered for making a formal analysis of the constitution of taste in a classroom.

Before the analysis is explained in detail, we give a brief outline of the analytical steps. First, we will demonstrate how the constitution of taste can be made visible and coded through the distinctions that the students make. To acquire taste amounts to developing habits of making distinctions of exclusion and inclusion as valued by the practice. Distinctions of taste are regularly valued by the participants in relation to norms current in the specific social practice. In the typical science classroom practice, the current taste usually originates from the teacher who distinguishes preferred ways of doing and talking science. Due to a diversity of reasons, for example home background or previous schooling, the individual student can or will acknowledge this taste to different degrees. As will be shown below, it is possible to observe and categorize how the participants in a classroom practice include and exclude utterances, actions, and persons in relation to norms that are explicitly or implicitly stated. Second, since students who do well in science do not necessarily like it, nor consider it something they can identify themselves with, it is also essential to examine how the students enjoy being part of the science classroom activities. This can be studied through how the students aesthetically judge the distinctions that they make in this practice. Third, we show how the constitution of taste can be observed also from humorous interactions in the classroom. Fourth, observations of the distinctions that students make need to be situated as part of events or activities with purposes. Being a typical educational practice, distinctions of taste in the science classroom are regularly associated with particular purposes and goals which the teacher has introduced, namely there is a scientific content to be learnt. Of importance for the constitution of taste, therefore, is the extent to which individual students, both cognitively and aesthetically, can acknowledge distinctions oriented towards these purposes. Or, in other words, to what extent do the students understand what they are set to do and how do they feel working towards these purposes. Distinctions of taste are thus associated with the learning of a particular content of science as relations of what is the case in terms of facts, phenomenon, and objects become, or not become, established. In the last step, we show how it is possible to observe to what degree the constituted taste (a) tallies with a taste beyond the classroom, that is, one that may be described as a taste compatible with science more generally (as recognized by other stake holders, e.g. by scientists or upper secondary school teachers), and (b) leaves room for contingent contributions arising in the moment or stemming from students’ personal experiences. This final step, then, is a description of the normative restrictions that are constituted in the classroom activities.

To be able to make an analysis of the constitution of taste as part of ongoing classroom practice, we use practical epistemology analysis (PEA). PEA builds on socio-cultural theory, John Dewey’s pragmatism and the later Ludwig Wittgenstein’s writings (Wickman and Östman 2002). Its purpose is to “understand what people say and do during authentic classroom work and what this tells us about how and what students learn by participating in the specific interactions of a certain curricular setting” (Wickman 2004, p. 326). PEA has been adopted in numerous studies (see Kelly, McDonald and Wickman 2012). The focus is the meanings people construe in action and the consequences these meanings have for the direction learning takes. As Richard Rorty notes, it is an anti-representational account, “which does not view knowledge as a matter of getting reality right, but as a matter of acquiring habits of action for coping with reality” (Rorty 1991, p. 1). It is, thus, not a report of what people know, feel, or like with certainty, but of the knowledge and values that the participants construe in talk and action in order to proceed with the classroom activity. In

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this respect, the analysis may be said to look at classroom processes from a teachers’ perspective.

Here we make use primarily of two of the concepts of PEA, namely relation and gap to analyze meaning-making in classroom interactions. Relations are established by the participants in an activity between the words and actions that already make sense in the situation. That words or actions “make sense” should here be understood in a strictly situational and actional sense; namely, how they in the specific moment contribute to the direction learning takes (Lave 1996) through the interlocutors’ bit-by-bit negotiations (Gee and Green 1998). That words are used in this way is seen when an interlocutor is adopting certain words or actions in the specific interaction as leverage for making sense of something not yet known to participants, that is, a gap. A gap means that the persons, in action or in communication, make evident that they need to make a relation to fill the gap. It is made evident in the conversation when the interlocutors ask questions or encourage each other to find out what is the case. The circularity here is intended and necessary, because a gap may or may not be filled with a relation. When a gap is not filled with relations acceptable to those interacting, it means that the activity has to stop or that they have to start over in a completely new direction. For the purpose of analyzing the constitution of taste, our interest is not in just any gaps or relations, but specifically those pertaining to situations where students made explicit distinctions and judgments of taste, meaning that they included certain relations to fill the gap while excluding others, and did this in response to posing a question, disagreeing, or hesitating concerning how to handle the situation. The following short exchange between two students illustrates the concepts:

Karl: Hassan, since you got a good view there, check how high it is!
Hassan: It has gone, like, two lines up.
Karl: [laughs] You can’t say it like that.
Teacher: Then you have to calculate how much two lines…
Hassan: Two millimeters.
Teacher: What is the value of each line?

Here Karl and Hassan were looking at a graduated cylinder to see how much the water surface had risen after immersing a weight. We can here see that Karl told Hassan that they needed to know something, because Karl said that they needed to check how high the water level was. This is technically coded as noticing a gap, in this specific case regarding how high the water level was. They agreed on that this gap needed to be filled as was evident from Hassan trying to fill it with a relation. The relation Hassan delivered was “It has gone, like, two lines up”. This is called a relation as he suggested a relationship between the words “gone up” and “two lines” to fill the gap (about how high it was). But Karl, as can be seen from his response, questioned Hassan’s relation by saying “You can’t say it like that.” In doing this Karl noticed another gap, which they needed to fill with additional relations. Here the teacher was seen to support the students with additional relations about how to fill these gaps, namely how to properly talk about how to measure the change in water level. This conversation continued until the students were able to make appropriate scientific distinctions about how to talk about this (see detailed analysis below). If these gaps had not been filled with such acceptable relations, these students would not have been able to continue with the task at hand together and develop the distinctions necessary for taking part in this classroom.

These gaps and relations are not studied as isolated occurrences, but as events constituted in encounters through action and communication as part of whole practices. They are of particular interest in studying the constitution of taste. This is because only gaps that are
noticed in action by the students can be filled with relations. The gaps noticed by the
students are thus an important part of examining how students learn to make distinctions of
taste in the science classroom. But also the relations construed to fill the gaps are important
to examine with regard to taste. The relations established by the students in classroom
transactions can be similarities or differences (Wickman and Östman 2002). In the example
above, Hassan can be said to having construed a relation of similarity between “it” and
“gone, like, two lines up”. In this way Hassan made a distinction of inclusion, that is, that
this is a relation which may count as belonging in the science activity. Karl, on the other
hand, made an exclusion in the last statement, indicating a relation of difference, namely
that “it” cannot be described as “gone, like two lines up”. Karl also related this exclusion
to laughter and, thereby, construed a relation in terms of an aesthetic judgment. In this way
students, by noticing gaps and filling them with relations, can be said to negotiate the
cognitive, normative and aesthetic distinctions that belong in the science classroom. To-
gether these processes can be used to examine the constitution of taste for science.

As we will argue below, each of these steps is needed as part of an analysis of how taste
is constituted in action in the science classroom. We want to emphasize once again that our
presentation should not be read as a demonstration that the students in this classroom
acquired a taste for science. Instead, it should be read as an outline of five important
constructs which can be used to examine how taste is constituted in the moment-to-
moment interactions between the participants of the science classroom as it would be
apparent to a reader. Whether individual students develop a certain taste or not cannot be
answered through the short examples that we present here. But the analysis we suggest
offers a way to observe instances in which taste for science is at stake in the activity and,
therefore, analyze in what respects the teaching affords or constrains the students to develop a
taste for the science taught. Neither should the constructs be understood as separate en-
tities. As will be seen, the constructs are indeed entwined and continuous in action. They
should best be understood as analytic distinctions for the specific purpose of our
methodology.

1. Observing taste as distinctions

In line with our previous theoretical discussion, the constitution of taste becomes ob-
servable through overt distinctions, which are the choices of actions and the judgments
people make in dealing with themselves, other people, objects and events as part of
classroom practices by construing certain gaps and relations. The choices of action are
evident through:

A **Procedures** distinguished, i.e. how students choose to proceed in action as seen
through the acts they include and exclude

B **Language usage** distinguished, i.e. the various representations of content and
phenomena that students decide to use, as seen through the words or other signs that
they include and exclude. Language usage is thus approached in a multi-
representational sense (Kress, Jewitt, Ogborn and Tsatsarelis 2001) and, therefore,
acknowledges the diversity of ways meaning could be construed in the science
classroom (e.g. using words, numbers, diagrams, or models)

C **Ways-to-be** distinguished, that is what kind of persons that students decide belong in
science class as seen through who they include and exclude

In choosing some procedures, language and ways-to-be rather than others, students are
making normative judgments. However, it is not enough that they simply do or say any-
thing; it must also be evident that they actively make a distinction. This can be
demonstrated when they include some procedures, language usages and ways-to-be, while at same time excluding others. Analytically we see this as students construe certain relations instead of others in response to an explicit gap that has been noticed. This is a way of making sure that the analysis focuses on those distinctions which are actually constituted in class rather than on those merely transacted habitually because they are already part of classroom practice. Dividing the distinctions made by students into these three categories should not be seen as the only possibility, but rather as a heuristic helping the analysis not to forget important ways in which people make distinctions in action. As will be seen they are intertwined.

A. Procedures distinguished  Taste involves developing certain ways to act by distinguishing certain acts as proper for a situation. Learning such procedures means noticing gaps about different possibilities to act and to inquire into alternative relations that may constitute ways to proceed in the situation. The following discussion between Erik, Ali, and Hassan illustrated one such event. In order to measure the volume of a weight the students needed to make sense of the scale on a graduated cylinder. In the following excerpt Erik, Ali and Hassan had just immersed the weight into the water of the graduated cylinder:

1. Karl: Hassan, since you got a good view there, check how high it is!
2. Hassan: It has gone, like, two lines up.
3. Karl: [laughs] You can’t say it like that.
4. Teacher: Then you have to calculate how much two lines…
5. Hassan: Two millimeters.
6. Teacher: What is the value of each line?
8. Teacher: But no, look and compare between steps.
10. Teacher: You do it in math on the number axis then we see that…
11. Hassan: Yes it is two milliliters.
12. Teacher: Between that line and that line, do we then know how much one of those small lines amounts to?
13. Karl: Ten
15. Teacher: Milliliters [whispers to Hassan].
17. Teacher: Milliliters [points at the graduated cylinder].
19. Karl: Thirty, forty, fifty, no it’s not, it’s…
20. Hassan: But I said that.
21. Hassan: But it’s milliliters
22. Teacher: Check that it’s right.
23. Karl: It’s five.
24. Hassan: Exactly, it’s two milliliters.
25. Teacher: Check that it’s right.
26. Hassan: Yes, exactly
27. Karl: But be quiet Hassan. Five, ten, fifteen, twenty, twenty-five, thirty, thirty-five, forty, forty-five…
28. Ali: It’s two milli- [to the teacher]…
29. Erik: No five, twenty-five, no five [to the teacher].
30. Hassan: It’s five.
31. Karl: Five between each step.
33. Hassan: It’s ten, yes it has risen two lines.

In turn 1 Karl wanted Hassan to read the scale in order to see the change effected by the immersion of the weight. This gap about how much the water had risen had to be filled with relations in order for the students to continue with the activity. Beginning in turn 3, however, another gap was noticed which concerned distinctions about how to proceed with reading off the scale of the graduated cylinder. In the turns which followed, these distinctions became observable as the students, together with the teacher, explicitly included certain ways of doing this while excluding others. Filling this gap thus entailed construing numerous relations that amounted to distinctions about how to proceed, for example using milliliters rather than millimeters and how many milliliters the distance between two lines corresponded to. The important thing here is not that students knew certain distinctions, but the fact that it can be shown that they were engaged in making certain distinctions for how to proceed, and hence, what counted as proper ways to act in this science lesson.

We argue that instances like this one, in which we can observe distinctions being made in action, are important to begin to understand how students may develop a taste for science. It is possible, for instance, that the way this was done in the example above, where the students and the teacher jointly negotiated how to proceed in class by making certain distinctions, may have a positive effect on these students’ opportunity to develop a taste for science. Indeed, we may imagine alternative courses of action less conducive to such a development. For example, the teacher could have downgraded the students’ suggestions as erroneous, or she could just have told them straight away how to read off the scale. However, as is evident from the excerpt this was not the case. Instead, different courses of action were open for discussion, offering the students the possibility to actively construe the necessary distinctions to proceed. As there is not just one way of making distinctions, it is a matter also of taste how the students and teachers decide to proceed with their undertakings. If certain procedural distinctions come to be made habitually in class, for example of how to read the scale, a taste for certain ways to proceed may be observed to have developed.

B. Language usage distinguished Taste also comprehends a preferred vocabulary, as well as other ways of using signs to communicate the content. This is perhaps most obvious through the ways in which the interlocutors include and exclude certain words, including analysis of both the gaps that the participants notice about what are the appropriate words to use and the relations where such preferences are construed. The following excerpt (turns 34–42) exemplifies this; the students had lowered the weight into the graduated cylinder and were now discussing the appropriate words to use in describing what has happened:

34. Susanne: Move away, now we’ve written, like this, you, we lowered the material, into, wait. Down into...
35. Amira: Why did it happen?
36. Susanne: Into the water into the can, don’t know what we lowered down.
37. Amira: I wrote like this: five, we lowered the weight in water, into the water-…, in...
40. Susanne: Graduated cylinder.
41. Amira: Into the graduated cylinder.
42. Susanne: Lowered the weight into the graduated cylinder. And...

This discussion contained explicit gaps about how to name the different objects needed to describe what happened when the weight was being immersed. Certain names for the graduated cylinder and the weight were included whereas others were excluded. A difference was construed to “can” (38) and to “material” (34), and a similarity to “graduated cylinder” (40–42) and “weight” (37, 42), respectively. Another example, which is not shown here, is one in which the students discussed how to describe what causes the water to rise when the weight was immersed. In this case they settled for “because it pushes away the water” rather than “It becomes heavy, there is tension in the water”. Also in the earlier excerpt, turns 1–33, the students made distinctions regarding language usage, for instance in choosing between “millimeter” and “milliliter”.

As before, the example illustrates an instance which potentially afforded the development of a certain taste for science. In this example, however, the students engaged in the negotiation of distinctions without the direct intervention of the teacher. Irrespective of why, the students obviously felt free to engage in a discussion of how to name the things used and, when doing this, they distinguished some words as better than others. Also as before, we can easily imagine alternative ways of how situations like these could be approached. The most obvious would be the behavior of actually distinguishing that there are preferred ways of talking in the science classroom, another one that the students do not perceive this kind of naming as something they are able to engage in in the first place. The judgments made by the students in the example above may be explained by the fact that the teacher recurrently stressed the importance of naming things. It is likely that practices where aspects of taste are habitually distinguished in certain ways by the teacher, for example how students were taught that there may be better and poorer ways to name objects in the science classroom, will affect the students’ opportunity to acquire a taste for science. The actual reason for why Susanne and Amira so carefully decided on proper words and what it meant for their long term development of taste is, however, beyond the scope of this paper. The main point here is, of course, that the constitution of taste is observable in action, as the participants engage in situated distinctions of how to talk in the science classroom.

It may be noted, finally, that in learning to make such distinctions as have been illustrated in the two examples, students were also engaged in conceptual development, although this engagement, with regard to taste, is operationally observed in the distinctions negotiated about language usage and ways to proceed.

C. Ways-to-be distinguished In order to study the constitution of taste in the science classroom, we also needed to document empirically what it meant to be distinguished as a person that belongs in science. It is well known that students talk about themselves and others as belonging to specific groups and subcultures and that certain characteristics may distinguish them as being a science student (Costa 1995), for instance being able to succeed in this difficult subject or having certain stereotypic traits of a science nerd (Schreiner 2006). In describing the constitution of taste it was thus necessary also to study the gaps and relations where ways to distinguish what kind of people should be included and excluded in science were constituted and whether the students could meet those standards or not. Below we illustrate also how this kind of distinctions can be observed in action. Only in this way can it be made evident how ways-to-be are constituted in different classes depending on their settings. The following two excerpts, where Hampus jokingly labeled himself as the brain in the group, was an example of this:
Hampus: I’m the brain so I’ll say what you should write and you write and later I copy you.

Johan: You? Brain!

Hampus: No, but.

Johan: Measuring volume...

That Johan disagreed with Hampus (44) constituted an explicit gap concerning who Hampus really is. This made Hampus take back his statement of him being the brain (45). However, they seemed to acknowledge that someone could be the brain in the science classroom. A closer analysis reveals that a similarity was construed between “brain” and “say what you should write” (43). Apparently, “the brain” was the one who knew what to write. By also construing a relation of difference between “Hampus” and “brain”, Hampus was excluded from being a person who makes proper distinctions in this class. Only those who were “brains” could make the right distinctions, and Hampus did not belong to that group. Later Hampus returned to this incident:

Johan: Okay, what shall we do?

Hampus: I don’t know. I didn’t listen.

Johan: Did you listen [to Mio]?

Hampus: I rely on you here, since I wasn’t the brain.

Johan: What shall we do [to Mio]?

Hampus: What have you written?

Johan: What it says there [the whiteboard].

Hampus: Oh, it sounds...

Mio: Write a hypothesis!

Johan: I do as Mio does.

The students were not sure about what they were supposed to do and Peter therefore asked Hampus for assistance (47). Hampus, maybe a bit grumpy, referred to the fact that he was not the brain in the group and hence trusted the others for guidance (50). When Mio uttered “write a hypothesis” (55) Johan said that he would do what she did (56). Here, again, Hampus construed a relation between “brain” and being able to make the right distinctions in class; in this case about what should be done.

These excerpts thus demonstrate how distinctions may be observed regarding how ways-to-be count in this science classroom. Here, the students distinguished what kind of people should be included and excluded in science (brains should be included and brains know what to write and what to do) and whether the students could meet those standards or not (Hampus did not meet those standards). As before, we could imagine other kinds of inclusion and exclusion that have less to do with the culture of science and more to do with the identity and background of students in terms of, for example class, gender, or ethnicity. This, in turn, should be expected to be closely related to the kind of lingual and procedural distinctions students make, for instance if male or female ways of behaving are given priority (Arvola-Orlander and Wickman 2011).

2. Observing taste as aesthetic judgments

The ways students engage in making distinctions treated above is a necessary step in analyzing the kinds of taste that are constituted in science class. However, it is just one step of identifying potentially important instances that can be further analyzed and coded concerning the distinctions that students construe as part of their activities. Indeed, we could imagine students mechanically making these distinctions and, so, successfully
proceed with the activity. But this alone cannot be used to describe the kind of taste for science that develops in class. Britt Lindahl (2003) made longitudinal interviews with students in compulsory school about how their interest for science developed over the years. She reported that many of the best science students did not decide to continue with science in upper secondary school, because they found science boring. Such students could not count as having developed a taste for science in their classrooms. This highlights the necessity to study in situ also how students value taking part in science class. The second step, therefore, was to study taste as aesthetic judgments and in this way include in the analysis also how students valued and enjoyed taking part in making certain distinctions in the science activities. We focused on the use of the aesthetic judgments in order to describe also the values that were constituted and developed as the participants made the kinds of distinctions described above. The reason for this choice was based on prior classroom research on the significance of aesthetic experiences in science and science education (Wickman 2006).

Operationally aesthetic judgments have been defined “as utterances or expressions that either deal with feelings or emotions related to experiences of pleasure or displeasure, or deal with qualities of things, events, or actions that cannot be defined as qualities of the objects themselves, but rather as evaluations of taste—for example, about what is beautiful or ugly” (Wickman 2006, p. 9). This definition has a long tradition that goes back to Immanuel Kant (Wickman 2012). In turns 2 and 3 we have already met the laughter of Karl in commenting on a distinction made by Hassan. But even more obvious judgments than laughter and gestures—although they may also be included—are the use of spoken language. Classroom studies have shown that aesthetic judgments are repeatedly used when teachers and students distinguish what should be included and what should be excluded in the science classroom (Wickman 2006). By studying aesthetic judgments it becomes possible to see how students value the inclusions and exclusions that are made. Positive aesthetic judgments are typically used about what should be included and negative aesthetic judgments about that which should be excluded in proceeding successfully with the activity. At the same time students are communicating their feelings for the distinctions that they make.

In one of the groups the following conversation took place when the students were discussing the gap regarding how to use the scale of the graduated cylinder:

57. Yussuf: Wait, how much is it between these [the lines on the graduated cylinder]?
58. Melissa: It is, like, ten between.
59. Yussuf: Is it?
60. Melissa: Yes!
61. Erik: Nice!
62. Yussuf: Wait, ahh, shit [starts to count the lines]!
63. Melissa: I mean, not ten between, but it ends up at ten. It is like nine between, or eight.
64. Yussuf: Err

We can see here how the students made procedural distinctions in response to an explicit gap, but also how they made evaluative aesthetic judgments in relation to how these distinctions helped them proceed. Erik made the positive aesthetic judgment “Nice” in a happy voice (61) in relation to Melissa’s solution in turn 58 and assertion in turn 60 about how to proceed. However, Yussuf made the negative aesthetic judgment “shit” (62) in failing to adopt Melissa’s finding when counting the lines on the graduated cylinder.
In analyzing the aesthetic judgments and their significance for the development of a taste for science, we do not mean that the number of aesthetic judgments should be counted, to see whether positive or negative judgments dominate. Rather we suggest that the aesthetic judgments must be understood as part of the activity as a whole and what they tell us about students’ possibilities to partake and their feelings for the practice. In this respect it should be noted that aesthetic judgments are typically used on the one hand in moments of anticipation of the consequences of making certain distinctions, and on the other hand in moments of fulfillment and consummation, evaluating the consequences of what actually occurred (Dewey 1934/1980).

The aesthetic judgments of Erik and Yussuf in turns 61 and 62 should be understood in this flow of student activities. Erik can be said to have made an aesthetic judgment of his expectations from Melissa’s finding, namely that they helped them finish their assignment. Yussuf’s judgments expressed the opposite. In this way the aesthetic judgments of students can be used to describe the rhythm of anticipation and consummation in class and what they feel in relation to this rhythm. If the activity on Yussuf’s part had stopped at turn 64, he had been left without a capacity to make the appropriate distinctions according to his own expectations as is evident from his aesthetic judgment in turn 62.

Another case of this tension between anticipation and consummation is where Peter was filling water into the graduate cylinder, and used the aesthetic judgment “perfect” to sum up what Melissa had achieved:

65. Peter: Yes, you should start by filling [inaudible].
66. Melissa: Shall I pour into that one [Melissa holding a beaker with water, “that one” = the graduated cylinder]?
67. Peter: Just to hundred!
68. Melissa: Yes I know.
69. Susanne and Peter: Stop!
70. Peter: Perfect!

Here Peter was using the aesthetic judgment “perfect” (70) as a consummative evaluation of the distinctions made of what constitutes “hundred” (67). At the same time he was also evaluating positively his anticipation and his feelings for the consequences of this moment of consummation for succeeding with the classroom tasks. Their body language (attentively fixating the scale) and their engaged voices demonstrated their emotional involvement in the task. Thus, including aesthetic judgments in the analysis in this way makes it possible to observe whether students, like Peter in the example, are emotionally engaged or not in making the distinctions necessary to proceed in this science class.

In a more long term perspective aesthetic judgments are an integral part of the development of taste. It is likely that the taste constituted in a practice where the participants recurrently use negative aesthetic judgments (e.g. disgusting, boring, bad and so forth) or where aesthetics are totally absent, would differ from practices where this is not the case. Moreover, we can also imagine that some students would benefit from getting value judgments clarified by the teacher or a classmate. Since it is not obvious why a certain distinction is aesthetically judged in a specific way, for example as being perfect or nice, this could be a matter of explicit instruction.

Not just acts may be judged aesthetically, but also the persons performing them. In the following example students again discussed the scale of the graduated cylinder and how to use it to measure the volume of the submerged objects:
71. Hampus: How much is one of those lines then?
72. Mio: One milliliter.
73. Johan: It increased ten milliliters.
74. Mio: Was that right [to the teacher]?
75. Teacher: Well, that is what you, that’s what you should figure out.
76. Johan: What?
77. Teacher: What’s the value of each line?
79. Mio: Two.
80. Teacher: He says five and you say two, now you have to discuss with each other about which one’s right and why
81. Johan: Okay, because it is like this. Because it starts like this, fifty…
82. Teacher: Mm
83. Johan: Fifty-five
84. Teacher: Mm
85. Johan: Sixty, sixty-five, seventy, seventy-five, eighty, eighty-five, ninety, ninety-five, one hundred
86. Teacher: Do you buy that?
87. Mio: Yes [laughter]
88. Johan: Who is the great?
89. Teacher: He proved it to you, didn’t he [laughter]?
90. Mio: Yes, but I only guessed

In this group Johan and Mio did not agree on the value of the lines (71–73). The value of each line was a gap that still lingered when the teacher approached the group (74). As with Karl and Hassan in our first excerpt, the teacher wanted the students to fill the gap by themselves and did not answer Mio’s question in turn 74. Instead she encouraged the students to find it out for themselves. For Johan the value of the lines made sense (turn 78) and he helped Mio so that she was able to make the right distinctions and fill the gap. The procedure to arrive at the value of the lines was highly valued in this assignment, as may also be seen from previous excerpts. The teacher explicitly acknowledged that there was a right way to do this (turn 80) which she also clarified by asking Mio “do you buy that?” (turn 86). Also the students agreed with the notion that there is a value in distinguishing the right actions. Johan used the aesthetic judgment “the great” about himself (turn 88). The consummation of the situation was also acknowledged by Mio’s and the teacher’s friendly laughter (87 and 89).

The negative and positive aesthetic judgments we here present are from short excerpts, to illustrate how they can be identified as part of situations in which distinctions of taste are made. It should be noted that negative aesthetic judgments do not by themselves indicate that students fail to engage in an activity. Negative aesthetic judgments are often used by people to distinguish the expectations related to certain things and ways to act. If such negative things and actions can be avoided, the negative consequences may not result, but rather a fulfillment expressed in positive aesthetic terms. Hence, negative aesthetic judgments are often used about what should be avoided so as to result in fulfillment (Wickman 2006). In the following excerpt Hampus made a negative aesthetic distinction regarding the effect of the weight on the water line (turn 94). The students were immersing their first weight into the graduated cylinder and were expecting the water line to rise:

91. Hampus: Be careful! [the weight is clattering in the glass cylinder]
Mio: [giggles] nice thud
Mio: All right, is it rising?
Hampus: It does not rise a damn shit
Peter: [giggles] can I see?
Hampus: Yes, it rose
Peter: What, it didn’t stand still at all, check this out

Such a negative judgment thus may express proficiency in making distinctions according to a norm. It is therefore important not to see aesthetic judgments as absolute, but as part of the situated rhythm of anticipation and consummation in class and how students’ feelings towards certain objects, events, actions of people as part of science are constituted in the long term in this process. Of special consideration here is humor, which often deals with irony and that which is not the case.

3. Observing taste as humor

Although humor is a vaguely defined concept it is an important constituent of taste (Kuipers 2006). It can be defined as “a comic, absurd, or incongruous quality causing amusement” (dictionary.com 2013-09-26). It can be seen as a sophisticated and more indirect way to make distinctions in relation to a certain practice. Here we focus on what in vernacular parlance can be referred to as jokes and joking, as it was the prevalent form of humor in this classroom. Joking entails saying something containing elements that should not be taken literally or seriously, but rather should be understood as serving the purpose of amusement. However, joking, as we will see, rarely is self-contained, but part of seriously distinguishing how to proceed with activities, how to use language and about who belongs in the science classroom. By its connection with amusement and laughter it also has aesthetic continuity. Joking thus can be said to be a way of trying to make amusing aesthetic judgments and certain critical distinctions continuous, which may (or may not be) more or less successful with consequences for the constitution of taste.

In the following conversation joking was dealing with norms of distinguishing ways to proceed and word usage. The student Peter was spinning a weight on the table, which was not part of the ascribed task, when the teacher approached him:

Teacher: What are you examining Peter [Peter spins the weight on the table]?
Peter: How many laps it can spin without…
Teacher: Before it faints [giggles]?
Peter: Before the energy ends.
Teacher: Before the energy ends?
Peter: Yes, it has to sound scientific.
Teacher: The energy part already?
Peter: Yes!

In turn 100, the teacher used a joke to distinguish Peter’s inappropriate ways to proceed. She was using the word “faint” in connection with a spinning weight and giggled. The joke established a relation that did not belong in science class, namely that a weight can faint. Peter responded by instead construing a relation to “energy” (101) and so showed that he did distinguish what language and procedures belonged in science class. Likewise, Peter explicitly related to current norms by also distinguishing what word usage was appropriate in the classroom: “it has to sound scientific” (103). Apparently, according to the teacher’s feedback in turn 104, this was a more legitimate scientific relation to spinning a weight. In
this excerpt the teacher and Peter mutually and in a supportive humorous way acknowledged various distinctions about what words and procedures belong in science class, and so constituted what counted as a taste for science in this situation.

This episode did not contain any explicit distinctions of norms about ways-to-be and what kind of person belongs in the science classroom, although it was dealing with it implicitly by distinguishing procedures and words which were related to how you may be distinguished in science class. However, there were situations where joking occurred about ways-to-be as a student. One example is the previously reported conversation between Hampus and Johan about who was the brain in turns 43–46. Hampus made a joke in saying “I’m the brain so I’ll say what you should write and you write and later I copy you” (43) whereupon Johan answered “You? Brain!” (44) and Hampus replied “No, but” (46). Here we could see that Hampus’s joke was not well received. Through his joke Hampus was exposing himself to the question whether the others actually were considering him as the brain who could tell them what to write. Johan took him literally and denied Hampus the status as being the brain. Thus Hampus’s joke was not received as such, that is, as being humorous and an occasion for amusement. The joke did encompass relations about ways-to-be according to the taste of the classroom. In this classroom and between these two students, these were the only examples where jokes about ways-to-be resulted in an exclusion of a student. But we can easily imagine situations where the students do not understand jokes either through their consequences for procedures, word usage or ways-to-be or find them amusing and so a positive aesthetic experience. In studying the taste that is constituted in the classroom and its consequences for student continuing participation it, therefore, seems necessary to describe both positive and negative instances of humor in these respects, because they are likely to have opposite consequences for the kind of taste for science that is constituted in the classroom. For example, Cathrine Hasse (2002) has shown how the use of in-jokes between students being “inside” a specific and prestigious scientific subculture had an excluding effect on the other participants in the same physics course. In the extreme case, making jokes touches other possible genres of humor like sarcasms, where those who belong make jokes about those who do not according to certain distinctions of taste. This may go either way, those with ways-to-be that belong in science excluding those that do not, or those who do not belong in science making jokes about those that belong.

4. Situating and observing the direction of taste

We have now presented three steps for analyzing how taste is constituted in action in a science classroom. These steps aid in identifying and coding the distinctions that are made with regard to what they include or exclude, and also how these distinctions are valued through the aesthetic judgments and humor observed. However, taste in relation to education cannot be analyzed only from contingent distinctions and momentary pleasure. The observations made through the first three steps need to be situated in relation to the purposes of the classroom activities. In other words, does the taste that is momentarily constituted in the classroom lead students towards the purposes and aims of the lesson?

In analyzing the direction of such progression two components need to be analyzed. First, the purposes of the specific lesson as given to the students need to be identified. These so called proximate purposes constitute information provided by the teacher which the students have to act upon in order to reach a certain goal (Johansson and Wickman 2011). For example, if the over-arching goal for a unit is attainment of an understanding of ecological principles, likely proximate purposes could be: what animals can be found in a typical lake, where in the water are the plants and algae, what is the pH and so on. Second,
we need to analyze whether the consequences of the distinctions that are made by the students are such that they go on with the proximate purposes of the lesson; that is, that the proximate purposes function as ends-in-view to the students (ibid.). Only if this is the case can it be said that students develop a taste for science specifically and not just any taste. In this fourth step, we thus examine whether the distinctions that are made under headings 1–3 are in line with the purposes of the science lesson or not. In doing this, it is often necessary to analyze a longer sequence to see how the distinctions become continuous with the purposes of the lesson.

In the lesson that was studied an explicit proximate purpose was to **measure the volume of differently shaped objects**. The talk and actions of Erik, Hassan and Ali when they had immersed the weight into the graduated cylinder (turns 1–33) exemplify distinctions of taste dealing with this purpose. As described earlier, for the boys to be able to determine the volume of the weight, several gaps were filled with relations, for example: what was the unit of the scale and how many milliliters did one line correspond to. In this case, the gaps that were noticed and the distinctions that were made, for example including milliliter and excluding millimeter, were in line, and thus continuous, with the proximate purpose of **measuring the volume of differently shaped objects**.

In her introduction, the teacher informed the students that an important aspect of doing inquiry was to properly name the things examined. Only by giving the different objects suitable names it was possible to communicate, both in text and talk, the result of the measurements. She repeatedly told the students that a name should capture some scientifically relevant quality of the object. For example, the weights might be categorized as the *small* and the *big* weight. Another proximate purpose during this assignment was thus **naming the objects**. In the following excerpt the students had just started with the assignment and were now talking about how they should proceed:

106. Yussuf: We start with these [the weights], they are the simplest [to measure].
107. Melissa: Okay, but we write down all the objects, right?
108. Yussuf: Object, what is this [the weight he is holding]? Fifty iron. It is, it says fifty on it.
109. Erik: Fifty grams
110. Melissa: Fifty grams
111. Yussuf: Fifty…
112. Melissa: No, how do you say, fifty….
113. Erik: Milligrams
114. Yussuf: Milliliters, no it can’t be
115. Melissa: No
116. Yussuf: Its weight is fifty grams
117. Melissa: Okay, fifty grams, yes
118. Yussuf: Fifty grams of iron

In turn 118 Yussuf said *fifty grams of iron* which was the name they hereafter used when they referred to this weight. Before they settled for this name, though, they filled gaps by including certain relations while excluding others. As with the previous excerpt, these distinctions about what should be excluded and included aligned with the proximate purpose of giving scientifically relevant names. That is, fifty grams of iron was judged being better or more appropriate than, for example, fifty milligrams and they could proceed with the activity. Giving the metal weight a name was thus a directional and normative process, which comes to an end when the gap was filled according to the purpose.
In this example the norms concerning making the right distinctions were both implicit and explicit. That is, the students acknowledged and worked their way towards an end-in-view and in this process some things were not questioned, for example that they should name the object at all, and some were questioned, for instance “no it can’t be”. Hence, by analyzing to what degree the students are making distinctions that orient them towards the purposes of the lesson, it is possible to determine the direction that the constitution of taste for science is taking in relation to classroom science norm. It is likely that in activities where the proximate purposes seldom or never function as ends-in-views, a taste for science will have few opportunities to develop among the students.

5. Reproducing and contingent aspects of taste

So far we have made evident how it is possible to observe how distinctions of taste relate and contribute to a current classroom taste for science. That is, we are now able to analyze how the participants include some ways-to-talk, ways-to-proceed, and ways-to-be while excluding others, how these distinctions are valued, and how this aligns with the specific purposes of the activity. However, from a wider stakeholder perspective, the taste developed may be judged as more or less conducive to a taste that is compatible with the use of science outside the classroom. This could regard distinctions of taste in relation to for example science as practiced by scientists or to socio-scientific issues. Some things that occur in the classroom may have unfortunate consequences for developing a taste that will be helpful also to such wider fields of use. Theoretically it would be possible to teach students a synthetic taste for science, which they joyfully can take part in, but which is of little assistance to deal with science in practices outside the classroom. It is likely that a taste for science may have some normative components that are more or less recurrent in science practices in general. For example, calling a beaker a beaker instead of calling it a glass is likely to be distinguished as a better way-to-talk in most scientific settings. Another example may be how experimental skills are valued; most certainly there are better and poorer ways to set up and interpret an experiment. It has been demonstrated that practical work can be perceived, both by teachers and students, as pleasant and sometimes spectacular distractions, but with little meaning for the understanding of the content or the scientific practice (Abrahams 2009). A science practice characterized by experiments not being continuous with the aims and goals of the practice, may thus construe a taste for science with little relevance or meaning outside this classroom. At the same time, situations are always unique and therefore there is no single unequivocal taste that either needs or can be acquired in a robot fashion. For this reason, it is important to analyze also to what degree distinctions of taste from individual students are given room in the process of construing the norms of science.

Hence, the aim of this last analytical step is to examine (a) to what extent the taste that is constituted in a particular classroom reproduces what is considered as taste for science outside the classroom and (b) how students are allowed to contribute with gaps and relations contingent on their differing individual experiences of the current taste concerning distinctions of better or worse ways to proceed, talk and be. Together, the reproducing and contingent aspects allow an analysis of how the classroom norms are related to the science curriculum as construed beyond the classroom, both to science and to other fields of importance to the students’ lives. Both these aspects may be significant for developing students’ taste for science.

In the classroom practice here used as an example, an important part of measuring the volume was to understand the scale of the graduated cylinder. During the assignment the teacher explicitly distinguished that an understanding of the scale was a necessity when
measuring things. She also repeatedly stressed that there was a favored way to arrive at this understanding, namely by counting the lines the same way you do in math class. Therefore, being someone that can read off a scale and also understand the underlying logic of it was likely to be important aspects of the scientific taste in this classroom. From the scientist’s perspective, this should be a distinction compatible with a scientific taste, because having an understanding of the scale is important in most scientific practices. As described earlier, the teacher and the students distinguished this normatively through ways-to-talk, ways-to-proceed, and ways-to-be. However, due to experiences of individual students, the process of reaching an understanding of the scale followed different routes as contingent gaps were noticed and filled.

In the following excerpt the teacher included a contingent joke from a student. In this example two different ways of naming things became visible, one in line with the scientific practice and one more general, and, apparently: funny. One of the students in the group told the teacher that they named the weight “small weight”. The teacher responded by saying “but that is really good” (turn 121). “Small weight” was thus valued as an appropriate name and the student could continue in the direction suggested by her.

119. Teacher: Those yes, precisely. One at a time. And then you name it something. This is a…
120. Kim: We wrote small weight
121. Teacher: But that is really good
122. Anna: Can you name it Jonny?
123. Teacher: It is a small weight
124. Anna: Can you name it Jonny?
125. Teacher: You can name it Jonny as long as you tell that Jonny is the small weight
126. Anna: All right
127. Anna: But we have not done that
128. Teacher: It works nicely, Jonny small weight
129. Anna: Immerse Jonny small weight
130. [laughter]

In turn 122 Anna humorously asked the teacher if it is possible to name the weight “Jonny”. The teacher did not brush this away but rather used the student’s suggestion to clarify the logic behind the scientific way of naming objects (turn 125): the actual name was not important as long as it captured the quality of the object (Jonny is the small weight). In turn 128 the teacher again acknowledged this by uttering an aesthetic distinction, “It works nicely, Jonny small weight”. The student found this funny and laughed when she jokingly included the, not so scientific, name with the scientific practice of the hands on activity: “Insert Jonny small weight” (turn 129). The teacher’s response to “Jonny” is an example of what it may look like when distinctions of a more everyday taste are negotiated and made continuous with the taste current in the science classroom. Instances like these, where distinctions of taste are playfully negotiated, are likely to be of importance for students’ opportunity to develop a taste for science.

Summing up the methodology

As we noted before, the detailed outline of the different analytic steps that we have provided was done according to a logic which we believe is best suited when these steps are first introduced to the reader. As we hope that, by now, the reader has appreciated both
the theoretical and empirical basis for each step, we now present another logic of the steps, one which we believe best suites the purpose of conducting a “taste analysis” of the moment-to-moment interactions in the science classroom. The summary below demonstrates step-by-step how the complete methodology could be used when analyzing the constitution of taste in a specific activity.

1. **Examine what the purposes of the activity are**  
The aim of the first step is to clarify the aims and purposes of the activity: What are students supposed to do and talk about? The proximate purposes are evident as the science related tasks the students are set to do by the teacher, for example giving the objects suitable names or measuring different shaped objects. Thus, in this step we ask:

- What are the proximate purposes of the activity?
- How are these purposes made clear to the students?

2. **Examine whether the distinctions of taste orient the students towards the purposes of the activity**  
In this step, distinctions of taste are analyzed as the choices of action evident through how students choose to include and exclude certain (a) procedures, (b) words or concepts, and (c) ways-to-be. Analytically, the constitution of taste is evident when the students chose a certain course of action and at the same time exclude another one in order to reach the proximate purposes. In classroom activities that have a positive effect on the constitution of taste for science, the proximate purposes need also be ends-in-view for the students. In principle this means that the students include procedures, words and each other in ways that are conducive to purpose. Thus, in this step we ask:

- Are the distinctions (language, procedures, and ways-to-be) made in line with or opposed to the purposes of the activity and so with the current classroom taste?

Together the first and second step can be used to see what kind of purposes and classroom interactions that are conducive to developing the normative and cognitive aspects of the current classroom taste. Clearly, teaching is central for the students to learn how to distinguish actions oriented to purposes and so developing habits of making distinctions of taste in the science classroom. Of importance is, for example, the proximate purposes introduced and how these, as a result of the doings of the teacher, become ends-in-view for the students. The proximate purposes not only need to be understood and so possible to act upon, but the students also need guidance in distinguishing preferred actions towards these. Therefore, the extent to which the participants are given opportunities to develop a taste is implicitly evident when these steps are analyzed. It is to be expected that practices where the proximate purposes never become ends-in-view will have a negative effect on the constitution of taste for science.

An important part of learning which distinctions are preferred in the science practice is to learn how these are aesthetically valued, and the next step in the analysis is to examine this, namely how students value and judge the distinctions of taste made in the classroom.

3. **Examine how the distinctions made are valued through aesthetic judgments and humor**  
In this step it is analyzed on the one hand how students aesthetically judge the inclusions and exclusions of ways-to-act, ways-to-talk, and ways-to-be, and, on the other hand, how they value the distinctions in terms of humor. Thus, in this step we ask:

- How are the distinctions that are made being valued by the students through aesthetic judgments and through humor?
In principle, this part of the analysis can be described as an examination of how students enjoy and value various distinctions and, so, enjoy being part of the practice. Also aesthetic judgments can be transacted habitually. It is not self-evident why, for example, it is better to say “graduated cylinder” than “can”, or why an experimental set up is described as neat. It is, thus, likely that settings where specific aesthetics of the practice are overtly discussed and negotiated may affect the development of taste for science positively. Again, the teacher has a central role for how this is to be realized.

However, although the taste constituted in the classroom may be in line with classroom purposes and also be enjoyed by the students, it will be of little further use if it is functional and valued in this specific practice only. It is, therefore, necessary to analyze to what extent the distinctions of taste are also continuous with the taste in other fields of use. The aim of the fourth and fifth steps in the analysis is to clarify this.

4. Examine how distinctions relate and contribute to the norms beyond classroom practice

This part of the analysis aims at examining to what degree distinctions of taste support the development of a scientific taste that is functional in other fields of use than the classroom. In this step we ask:

- How do the distinctions relate and contribute to a taste for science that is current beyond the classroom?

In our data, acknowledging the understanding and usage of a scale exemplifies distinctions of taste that can be said to be compatible with a scientific taste as practiced by a scientist. It is likely that this norm will be acknowledged not only if the students enter upper secondary school or an eventual tertiary science educational program, but also in various every-day situations where an understanding of measurement is required. This step is crucial to establish whether the taste developed has a place in society generally. It is possible that classroom practices where science always is distinguished as “spectacular experiments” or, maybe, the opposite; “science is the transmission of known facts” may advance a taste for science with no persistent meaning outside these settings.

At the same time, the constitution of taste cannot be a universal process having the same crucial components in every classroom and to every student. On the contrary, the development of taste is a social process open for the contingent contributions of the individuals in the specific classroom setting. The aim of the fifth and last step in the analysis is to examine how the distinctions of taste support the development of a taste that is functional in fields concerning the students’ everyday lives.

5. Examine how distinctions that include students’ various idiosyncratic experiences are allowed.

In this step we therefore ask

- How are students allowed to make their personal contributions to the taste developing in the classroom?

Hence, when analyzing the reproduction of a taste in the science classroom that is current beyond its walls (step 4), individual distinctions necessary for construing these norms should be analyzed too (step 5). We can imagine a diversity of instances where a development of taste is both supported and opposed as a result of how the more everyday distinctions of the student are acknowledged. For example, practices recurrently downgrading individual distinctions will most likely have a negative effect on the development of taste for science.
Together the five steps and six questions make it possible to analyze what kind of taste that is constituted in the classroom and how the various components described in each step interact in its development.

**Discussion**

In this paper we have developed a methodology for examining how taste for science is constituted in the moment-to-moment interactions of the science classroom. This is done by identifying instances in which the participants of the classroom respond to explicit gaps by making distinctions about ways to talk, act, and be, and analyzing how these distinctions align with the purposes of the classroom, how they are judged aesthetically (including humor), and how they align with other norms outside the classroom, both those of science and those relating to the students’ lives more generally. The purpose of the method is thus to enable empirically grounded accounts of how, and what kind of, taste for a subject is constituted in situated practices and how the various encounters that occur in those practices may contribute to the development of such a taste. As argued in the paper, our primary interest is the understanding which the methodology may generate in terms of what a teacher can do to help students acknowledge, learn, and appreciate the taste distinguished in the science classroom. The uniqueness of every individual classroom, for example in regard to student group background or teaching style, suggests that there is a variety of ways in which enjoyment and competence could develop towards what is usually recognized as an interest in science. Consequently, there should be a variety of ways through which this process could be supported by a teacher. However, although the data that we have used to develop the methodology give some examples of how such teacher-student transactions may influence the taste that is constituted, empirical research specifically addressing this process is needed, before any claims can be made. Again, the analysis of data made here has the single purpose of developing and illustrating the methodology as such.

The method that we suggest could make an important contribution to the field of students’ interest in science precisely because it offers a way of connecting the results from more psychologically oriented studies with analyses of the situated constitution of taste in real classroom interactions. Clearly, having an interest in science is not only a matter of feelings or motivation. Indeed, one could argue that there are at least three different ways in which interest may reveal itself in a young person’s actions, namely (a) how they take part in science class, (b) how they may consider science as a future career choice, and (c) how they include science as a relevant part of their daily lives. Here we have used the methodology to investigate mainly (a) although it may touch upon also (b) through the choice of a school where an unusually high proportion of students apply for the Natural Science Program. However, if we want to begin to study the detailed mechanisms which are at work when students develop an interest for science in any or several of these respects as a result of what happens in school, this can be done by the methodology that is outlined here. Naturally, before any final judgments can be made on the benefits of this approach, the methodology need to be supported with more evidence from other content areas, grade levels, and classroom settings. In a preliminary study, therefore, other science practices have been analyzed using the methodology presented (Anderhag, Hamza and Wickman in review).

Certain more general aspects of classroom contexts have been reported to have a potential impact on student attitudes toward science (Tytler et al. 2008). We know for
example that students with positive experiences of science often refer to an engaging or passionate teacher (e.g. Boe, Henriksen, Lyons and Schreiner 2011). Other factors suggested to have a positive effect are for example laboratory work (Hofstein and Lunetta 2004) and activities emphasizing socio-scientific issues (Tomas and Ritchie 2012). At the same time, it is well known that while students value labs in some general sense, in specific classes that may not be the case (Säljö and Bergqvist 1997). This is not surprising considering that learning, and therefore also the development of taste, is a situated and contingent process. By examining how science is distinguished, valued and made continuous in classrooms characterized by different ways of teaching such as the ones mentioned above, it should be possible to empirically explore the consequences different kinds interactions, with for instance laboratory materials, with socio-scientific issues or with teachers, have for the taste constituted in the classroom.

The active role of the teacher with respect to how proximate purposes are chosen, valued, and made continuous may be an important focus for such a study. For example, what purposes are stated in a setting where students perform laboratory work, what skills are acknowledged and made continuous and how are these judged through aesthetics and humor, and do students distinguish themselves as members of a certain practice? Another question may be how a more generally applicable taste develops through the taste of the more proximate classroom purposes and in interaction with students’ more personal taste. Such a study would be a complex enterprise, but at the same time a way to establish what progressions for learning a taste for science may look like under various circumstances.

Although there may be similarities regarding how science is distinguished in different classroom settings, it is likely that the taste constituted will also show significant differences between the settings. We therefore believe that the aim of further studies should not be so much to determine if there is a one and only preferable or more successful taste for science, but rather to describe empirically how taste is constituted in different practices. Nevertheless, there is probably also a possibility to make more general conclusions about how students become socialized into science practices. For example: What science is consolidated and developed at different levels in the educational system? How do the teachers and their students distinguish this science? How may the teacher support progressions of students? How important are students’ contingent and personal distinctions of taste for the development of habitual distinctions of taste? Studies examining questions like these have the potential to increase our understanding of why some settings are more successful than others in developing a certain kind of taste for science.

It is well-known that students turn away from science at an age corresponding to the transition from lower to upper secondary school and that this decline to some extent corresponds to experiences from science class (Lyons 2006). Although there is a diversity of explanations for this decline, it is likely that, at least partly, this can be associated with how science is normatively construed at different levels in the school system. There is also evidence that different sub-groups of students value and appreciate different aspects of their school science (Tytler et al. 2008), and that, as described in the beginning of this paper, students from some social groupings have difficulties to relate to science whatsoever. At the same time there are interventions that show how also students with little taste for science may find rewarding qualities in the school subject (Calabrese Barton 2003). In addition to the possibility to study the taste that is distinguished at different educational levels, it should also be rewarding to study taste for science in different socio-economic and cultural settings. A possible outcome from a more comprehensive investigation could thus be a greater understanding for how teachers and students construe a taste for science which fits with different identities (cf. Brickhouse et al. 2000).
Moreover, the highly situated activity of making and responding to jokes and what it means for valuing science is poorly understood (Hasse 2002). As shown in this study, humor can be used to distinguish taste in a, seemingly, constructive way. That is, through humor the teacher and the students acknowledge ways-to-talk, ways-to-proceed, and ways-to-be. At the same time humor can be used for exclusion. It is likely that humor, as well as the other signs of taste that we discuss in this paper, are important features in school generally. We therefore expect that the study of taste could be useful in other school subjects as well.

Although the backdrop for the methodology was partly motivated by the reported decrease in interest for science, our intent is not that every student should choose a science educational career. Rather we argue that there is not a single taste for science. Each and every socially and personally situated taste needs to be acknowledged by educational researchers, so that we can better understand and support the various roles that science may have in young people’s lives.

References


Signs of taste for science


**Per Anderhag** is a PhD-student at the Department of Mathematics and Science Education, Stockholm University, Sweden. His research focuses on how interest in science is constituted in classroom action.

**Per-Olof Wickman** is a Professor at the Department of Mathematics and Science Education, Stockholm University, Sweden. His main research interest is the constitution of science content and its values in social interaction.

**Karim Mikael Hamza** is senior lecturer in science education at Stockholm University. His research focuses on developing and refining didactic tools for teaching science, primarily together with practicing teachers.
Extending methods: using Bourdieu’s field analysis to further investigate taste

Alexandra Schindel Dimick

Abstract In this commentary on Per Anderhag, Per-Olof Wickman and Karim Hamza’s article Signs of taste for science, I consider how their study is situated within the concern for the role of science education in the social and cultural production of inequality. Their article provides a finely detailed methodology for analyzing the constitution of taste within science education classrooms. Nevertheless, because the authors’ socially situated methodology draws upon Bourdieu’s theories, it seems equally important to extend these methods to consider how and why students make particular distinctions within a relational context—a key aspect of Bourdieu’s theory of cultural production. By situating the constitution of taste within Bourdieu’s field analysis, researchers can explore the ways in which students’ tastes and social positionings are established and transformed through time, space, place, and their ability to navigate the field. I describe the process of field analysis in relation to the authors’ paper and suggest that combining the authors’ methods with a field analysis can provide a strong methodological and analytical framework in which theory and methods combine to create a detailed understanding of students’ interest in relation to their context.

Keywords Science education · Social reproduction · Critical theory · Student interest · Methodology
Per Anderhag, Per-Olof Wickman and Karim Hamza’s article, *Signs of taste for science*, is grounded in one of the central themes of the study of culture and education: the concern for the role of education in the social and cultural production and reproduction of inequality. Various social change theorists have examined “the repertoire of social practices through which families, students, and educators themselves re-make their own class-consciousness, largely through their complicit participation in the mechanics of the system” (Stambach 2012, p. 324). Anderhag, Wickman, and Hamza’s article proposes a methodological tool that is situated neatly within this concern for social change, and more specifically, the concern for the ways in which science classroom experiences produce, continue to reproduce, or transform the outcomes of students’ choices to persist in science education. In making their case for this methodology, they specifically choose a school to illustrate their methods that appears to be “counteracting the cultural background of their students.”

Through this work, they hope to demonstrate the constitution of a taste for science through a micro-level analysis of classroom discourse. Anderhag, Wickman, and Hamza’s analytical tool can be used within science education research to explore the processes at play in classroom learning and in students’ constitution of a taste for science. A research method such as this one, which enables researchers to study the moment-to-moment interactions that occur within a classroom, can potentially speak to questions of access to and participation in science. The authors suggest this in their description of taste, stating it “may thus affect the extent to which people are successful in, and also are given access to, different practices”. Anderhag, Wickman, and Hamza propose a methodology that is perfectly adequate for their purposes—studying “the detailed mechanisms which are at work when students develop an interest for science” through how they take part in a science classroom. However, by engaging in a Bourdieuan analysis, they open the way to several different possible questions and modes of analysis. In my comments, I wish to examine some of these additional opportunities.

Anderhag, Wickman, and Hamza’s micro analytical tool has a significant role to play, and I would like to suggest that one role it should play is in conjunction with other methods that allow for deeper analyses that extend over time. While the methodological tool they describe allows for a fine-grained analysis of what occurs within specific interactions, such moment-to-moment interactions can also be analyzed within the context, or the social fields, in which they occur. In this commentary, I suggest that other scholars who wish to understand how students develop an interest in science within situated contexts can do so by building upon Anderhag, Wickman, and Hamza’s methods to include Pierre Bourdieu’s recommendations for analyzing fields. By situating the constitution of taste within Bourdieu’s field analysis, researchers can explore the ways in which students’ tastes and social positionings are established and transformed through time, space, place, and students’ ability to navigate the field.

**Bourdieu’s field analysis**

Bourdieu’s (1984) theoretical contribution has primarily been understood as a critical analysis of social change and power through cultural production. Bourdieu sees power as socially and structurally created. For Bourdieu, power is synonymous with the accumulation of capital, and he examines the processes through which capital is accumulated and utilized through his observations of distinction. As humans, we are constantly in the process of differentiating ourselves from others as we construct markers of distinction to
indicate similarities and differences, inclusions and exclusions. This constitutes the creation of both objective and subjective boundaries in terms of ideas, interests, commitments, histories, and, as Anderhag, Wickman, and Hamza emphasize, tastes. Bourdieu (1984) states:

Taste classifies, and it classifies the classifier. Social subjects, classified by their classifications, distinguish themselves by the distinctions they make, between the beautiful and the ugly, the distinguished and the vulgar, in which their position in the objective classifications is expressed or betrayed. (p. 6)

As this statement demonstrates, Bourdieu’s analysis of cultural production is fundamentally and inextricably relational, and as Anderhag, Wickman, and Hamza state, “varying and changing through space and time”. That is, cultural production is situated within and constituted in relation to others and is not static.

One cannot create a distinction outside of a social field, but rather it is formed in relation to that social field. Students from culturally dominant groups, and whose ways of being align easily within culturally dominant spaces, such as classrooms, may inhabit such spaces with the cultural dispositions to which they are already well-suited (Bourdieu and Passeron 1977). However, their position is only distinguished, or made secure, in relation to others, who may not inhabit the space with as much ease. Bourdieu refers to these spaces as fields, or the settings in which the actors (students and their teacher in the case of Anderhag, Wickman, and Hamza’s article) and their social positions are located. Bourdieu (1993) describes the relational significance of social positioning as follows:

[E]ach position is subjectively defined by the system of distinctive properties by which it can be situated relative to other positions; that every position, even the dominant one, depends for its very existence, and for the determinations it imposes on its occupants, on the other positions constituting the field; and that the structure of the field, i.e. of the space of positions, is nothing other than the structure of the distribution of the capital of specific properties which governs success in the field and the winnings of the external or specific profits… which are at stake in the field. (p. 30)

In Anderhag, Wickman, and Hamza’s article, the classroom represents one social field that lies within another, that of the school, which is in turn a part of ever widening social fields. The fields in which the students operate are of significance, because students are social actors who will engage in social positioning and interaction in relation to social fields, regardless of whether they are consciously aware of them.

Anderhag, Wickman, and Hamza’s proposed methodology includes two final steps that relate to the study of social fields and which can potentially provide a more in depth level of analysis of the micro-level interactions viewed within the paper. In step four, the authors recommend examining whether “distinctions relate and contribute to a taste for science that is current beyond the classroom”. And, in step five, they recommend judging taste “as more or less conducive to a taste that is compatible with the use of science outside the classroom” both in terms of the practice of science and in students’ everyday lives. Both steps can be viewed as relating the classroom interactions to social fields. In this commentary, I contend that broader analytical implications, such as how different students might navigate and cross borders within science learning environments, can emerge when researchers examine the ways in which moment-to-moment classroom interactions exist and are produced in relation to social fields.
Pierre Bourdieu and Loic Waquant (1992) suggest performing field analysis through three “necessary and internally connected moments” (p. 104). This is described as follows:

First, one must analyze the position of the field vis-à-vis the field of power… ([for example], ‘a dominated fraction of the dominant class’). Second, one must map out the objective structure of the relations between the positions occupied by the agents or institutions who compete for the legitimate form of specific authority of which this field is the site. And, third, one must analyze the habitus of agents, the different systems of dispositions they have acquired by internalizing a determinate type of social and economic condition, and which find in a definite trajectory within the field under consideration a more or less favorable opportunity to become actualized. (pp. 104–105)

As Bourdieu contends, these three aspects of field analysis are inseparable. Given this, in the following three sections of the paper, I will attempt to use Bourdieu’s methods of field analysis to propose ways researchers might analyze the field in relation to the micro-level analysis described in Anderhag, Wickman, and Hamza’s article. To do this, I will first describe an example from the article that will be used for further analysis.

Within the manuscript, there are two interactions between a student called Hampus and other students. In these interactions the students distinguish “the brain” as a person who knows what to write and how to “make the right distinctions” in class. They distinguish Hampus as not being the brain for the group and later Hampus reiterates this distinction in the following excerpt:

1. Johan: Okay, what shall we do?
2. Hampus: I don’t know. I didn’t listen.
3. Johan: Did you listen [to Mio]?
4. Hampus: I rely on you here, since I wasn’t the brain.
5. Johan: What shall we do [to Mio]?
6. Hampus: What have you written?
7. Johan: What it says there [the whiteboard].
8. Hampus: Oh, it sounds…
9. Mio: Write a hypothesis!

Anderhag, Wickman, and Hamza highlight the significance of the students’ distinction, stating:

These excerpts thus demonstrate how distinctions may be observed regarding how ways-to-be count in this science classroom. Here, the students distinguished what kind of people should be included and excluded in science (brains should be included and brains know what to write and what to do) and whether the students could meet those standards or not (Hampus did not meet those standards). As before, we could imagine other kinds of inclusion and exclusion that have less to do with the culture of science and more to do with the identity and background of students in terms of, for example class, gender, or ethnicity.

As the authors highlight in this statement, students’ development of a taste for science does not exist only in relation to itself, but instead is constituted relationally with others and within broader contexts, or fields. The following sections extend the concept of how taste exists relationally through a discussion of Bourdieu’s field analysis.
Position of the field vis-à-vis the field of power

How might one construct a field? The primary field Anderhag, Wickman, and Hamza are concerned with is that of science education. And yet science education is both broad and a bit abstract in terms of the authors’ approach to classroom analysis. Since their primary concern is with students’ access to and participation in science classroom learning, and its connection to students’ potential pursuit of and success in additional science education, the most fruitful approach to identifying fields in their analysis may be to identify sites of struggle and what the struggle is over. Identifying the field includes clearly describing it—the boundaries of the field, who has access to it, how actors are positioned due to the capital they bring, etc.—and situating it in relation to fields of power both within and outside the classroom—“What are the historical, social, cultural, political, or economic factors that have led to this setting of the field?” (Mutch 2006, p. 163). The field of struggle that is identified in this science classroom might be situated within additional fields, including: the school context; the neighborhood, parental, and business community who participate as stakeholders within the school; the curricular context of the school and within which the students’ teacher works; national contexts of science education reform; globalized discourses and policies that increasingly influence science education curricular reforms across international borders; and powerful discursive practices that can influence science experiences and may lead to the inclusion or exclusion of students on the basis of class, gender, ethnicity, sexuality, or otherwise.

Anderhag, Wickman, and Hamza suggest that taste must be analyzed in relation to its applicability outside any single science classroom (steps four and five of their methodology). In the authors’ example, students engage in scientific practices within a laboratory experience in which students enact measurements. This instructional pedagogy, to which students conform and within which they distinguish themselves, would likely be necessary across multiple settings, as the authors contend, as this form of scientific practice is useful in more advanced science education or work. Additional questions about this and other instructional practices lie in how the overarching instructional purposes in the classroom relate to broader fields of power. Do the instructional practices reinscribe or subvert dominant relationships of power? Does the classroom purpose include a broader commitment to counter-hegemonic social movements (e.g. Freire 2000)? Does the agenda attempt to advance students’ abilities to escape poverty by gaining traction with forms of scientific cultural capital that are accepted within the current systems of power that include testing, advancement, and credentializing? Understanding the way the classroom is situated related to larger fields of power is essential to understanding how taste realized within a classroom space in Anderhag, Wickman, and Hamza’s analysis may be applied by students within or outside of a science context to achieve various purposes.

Positions of actors

This aspect of the field analysis considers the relative positions between various actors and the interrelations that are legitimized within those positions. In Anderhag, Wickman, and Hamza’s example, the students and teacher are the primary actors who hold positions within the classroom. The relative positions of the actors can be best understood when viewed in terms of Bourdieu’s notion of capital. According to Bourdieu (1997), capital refers to an individual’s accumulated wealth of knowledge (both knowledge about and knowing ‘how to’) that can permit a person to produce more capital. Capital, which is
synonymous with power for Bourdieu, can be cultural, social, or economic. Possession of specific cultural capital can be used under certain conditions to interact with others in a field where that cultural capital is valued, and in some instances cultural capital can be converted into wealth. Social capital refers to one’s accumulated networks of acquaintances, which can be drawn upon to establish greater economic and cultural capital. Capital is also relational and, as Bourdieu explains, “does not exist and function except in relation to a field” (Bourdieu and Wacquant 1992, p. 101).

Not all cultural capital will be valued equally, and, in particular, the knowledge and ways of being of dominant groups tend to be valued more highly within society’s institutions, of which schools are a part (Gale and Densmore 2000). Likewise, not all teachers will prize students’ capital similarly, but instead some teachers will view students in relation to one another and as having more or less value within their classrooms. This can potentially afford certain students cultural and social privilege over others. For example, students with dominant forms of cultural capital may position themselves in particular ways in order to receive higher marks or letters of recommendation so they can achieve a subsequent academic goal. Additionally, some students may be better equipped to navigate science classroom structures because they are better able to perceive of the ‘ways to be’ within the science classroom.

Returning to the example of Hampus (above), questions about Hampus’ position relative to other students arise. As the authors suggest, additional distinctions of inclusion and exclusion might be observable within the classroom setting. In this example, students experience science education within a particular classroom setting where students may struggle with one another for attention or to be seen as the ‘brain’ by other students or their teacher, or they may compete for grades and class standing. Understanding these inclusions and exclusions requires field analysis to determine how distinctions are made in relation to other actors within the field. For example, how does Hampus navigate his position with his peers and how is this related to the field of struggle identified? Was this interaction typical for Hampus in science? And is this sort of interaction typical for Hampus across multiple classrooms within the school? Are there other settings in which Hampus is ‘the brain,’ or is considered able to know and do what is needed to meet expectations? How is Hampus able to navigate his role within the science classroom over time? Does it change, and, if so, why and how? Such questions can help us to understand how the authors’ analysis of the constitution of taste may relate to the interrelations that students and their teacher create or legitimize within the classroom. Notably, this part of the analysis is intimately tied to the prior portion as actors within the field may compete for, contest, or challenge “the legitimate form of specific authority of which this field is the site” (Bourdieu and Waquant 1992, p. 105).

Habitus

Here we can examine how a student’s habitus may interact with the field such that they are more or less successful in actualizing their experiences. In Bourdieu’s (1990) words, habitus can be viewed as:

systems of durable, transposable dispositions, structured structures predisposed to function as structuring structures, that is, as principles which generate and organize practices and representations that can be objectively adapted to their outcomes without presupposing a conscious aiming at ends or an express mastery of the operations necessary in order to attain them. (p. 53)
Habitus can inform our tastes and actions, which may influence one to feel and act in determinative ways. Habitus might also be understood as ways of being that exist in relation to the dispositions and tastes which characterize it. It is frequently referred to as a “feel for the game” (Bourdieu 1990, p. 66), where the game represents the field and the feel for it is the habitus.

Habitus can be viewed as a fluid, rather than static, construct, and may be seen to change over extended lengths of time (Navarro 2006). Much of Bourdieu’s work theorized society, but his theory of habitus can also be used to examine social change and transformation. Researchers can potentially analyze the ways in which one’s habitus interacts with a field. Alistair Mutch (2003) explains:

There are factors, and something like habitus is one of them, that condition the extent of difference between different contexts. The analytical interest lies in the extent to which such dispositions are challenged by and altered by different practices, or to what extent they remain immune to such influences. (p. 397)

It is within this recognition of fluidity that Anderhag, Wickman, and Hamza develop their methodology to examine the constitution of taste in practice. The authors have sought to employ a method that can identify the potential classroom experiences that might influence this fluidity.

In extending the methods to include this third aspect of the field analysis, we can return again to the example of Hampus. Here it is significant to examine the individual’s constitution of taste within a broader context that situates its constitution both within the field and alongside one’s habitus. As one example, with a deeper understanding of Hampus’ background, the interactions between Hampus’ habitus and his ability to navigate the complex classroom settings with peers or to navigate the technological or cultural skills required for science classroom experiences might be analyzed. Further, understanding the boundaries of the field (part of step one above) allows researchers to explore whether he crosses those boundaries and what boundary objects might facilitate such crossings. At the same time, students may need to be explicitly taught the ‘rules of the game,’ or how to operate within the code of power, in order to access or challenge how the classroom or their classmates operate (Delpit 1995).

**Conclusion**

Bourdieu’s work has not been applied extensively within science education (for exception, see e.g. Brandt et al. 2010) and a renewed focus on Bourdieu may forward additional research applying his theories of social change and reproduction to science education. Furthermore, the authors’ carefully detailed description of the constitution of taste allows for others to envision and apply this construct to their own work. Many current forms of teaching science are not inclusive and open—do not help students develop sufficient capacities for taste in science—and, thus, understanding the development of taste may help determine whether particular schooling practices are more or less beneficial to the development of taste in different settings and with different student populations.

In suggesting that field analysis might be used in conjunction with Anderhag, Wickman, and Hamza’s methodology, I underscore the field as the “critical mediation between the practices of those who partake of it and the surrounding social and economic conditions” (Bourdieu and Wacquant 1992, p. 105). By exploring this mediation, it is possible that micro-level analyses of a school or classroom as a social field can move “research findings...
out of case-bound specifics” (Mutch 2006, p. 171) and reveal insights into how the findings might be operating in similar situations within other social contexts and fields. I view a micro-level analysis of taste working in conjunction with a field analysis much like a camera lens might be used to focus on an accurate picture of the broad context in one instance and a sharper view of the micro details in the next. Each picture offers a different story, and in some cases a more complex and rich narrative will emerge from a blending of the two.

References


Alexandra Schindel Dimick is an Assistant Professor of Teacher Education in the Department of Learning and Instruction at the University at Buffalo. Her research focuses on issues of equity, power, and social justice in science education. In her current research, she explores youth’s civic environmental identities and the ways in which curricular experiences further shape these identities and youth’s beliefs in themselves as agents of change.
How can teaching make a difference to students’ interest in science? Including Bourdieuan field analysis

Per Anderhag · Per-Olof Wickman · Karim Mikael Hamza

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Abstract In this article we respond to the discussion by Alexandra Schindel Dimick regarding how the taste analysis presented in our feature article can be expanded within a Bourdieuan framework. Here we acknowledge the significance of field theory to introduce wider reflexivity on the kind of taste that is constituted in the science classroom, while we at the same time emphasize the importance of differentiating between how taste is reproduced versus how it is changed through teaching. The contribution of our methodology is mainly to offer the possibility to empirically analyze changes in this taste, and how teaching can make a difference in regard to students’ home backgrounds. However, our last two steps of our taste analysis include asking questions about how the taste developing in the classroom relates more widely in society. Schindel Dimick shows how these two steps can be productively expanded by a wider societal field analysis.

Keywords Interest · Taste · Aesthetics · Science education · Situated learning · Norms · Values · Methodology

We would like to take the opportunity to thank Alexandra Schindel Dimick for her thorough discussion of our article, Signs of taste for science: A methodology for studying the constitution of interest in the science classroom and we appreciate her reading as a productive way of pushing the use of Bourdieu further. As we understand it, the scope of the methodology—studying the constitution of interest in the science classroom—is not questioned, but rather Schindel Dimick discusses how the supplement of field analysis may
be used to expand our understanding of how the societal structures of science education are manifested and interrelated from macro to micro levels.

Schindel Dimick discusses how our methodology can be complemented by adopting Bourdieu’s concepts of power, field and habitus. In her article, Schindel Dimick thus points to a possible method for examining structures evident at the macro level and how these are constituted and eventually also reproduced in the science classroom. Consequently, the forum provides suggestions for an approach to how distinctions of taste are reproduced in science education. In large, we concur with her suggestions, because combined approaches are needed if we want to understand how inequities are reproduced in society and so possibly can be counter-balanced by education. The suggestions presented in the forum seem well-suited for such an enterprise.

Since power, field and habitus are intimately intertwined with taste, but little referred to in the feature article, we will initially elaborate on the underpinnings of the research project in which the taste analysis was developed. This will serve as a background to our comments on some of the issues raised in the forum article.

The role of the taste analysis in the research project

The taste analysis is part of a research project in which we are examining what difference teaching can make for students’ interest in science. Our focus is situated within the European educational field of didactics (Wickman 2014), which in this particular case means that we are interested in how teaching may support students’ opportunity to pursue in the science classroom. As we make a micro-analysis we do not merely draw on Bourdieu’s work, but also on practical epistemology analysis as building on particularly John Dewey’s work on continuity (Östman and Wickman 2014). Students’ interests in science do not only concern their attitudes toward the subject of science and how it is taught, but their interest is also dependent on their capability and will to participate in the normative, value-laden, and contingent practices of school science (e.g. Carlone, Haun-Frank, and Webb 2011). Accordingly, participating in science is not only about learning what is the case in terms of scientific facts, but also learning their continuity with the norms and the values of the practice, that is: to learn a taste (Wickman 2006). The methodology suggested is intended to study how teaching may change the taste of young people, and especially of those who come from disadvantaged home backgrounds in this regard.

Students’ familiarity and identification with the taste that is transacted in the science classroom are not only influenced by the teaching the students encounter, but equally important are also home background. This suggests that some students are at risk of becoming excluded from science, but also that teaching in science should have the potential to counter-balance inequities related to home background. In the project we approached this tension between education and home background by searching for classrooms where the teaching in science–and not the background of the students–was the reason for the observed science interest. In other words, we wanted to find examples of science practices where the teaching in science made a difference. In a previous quantitative study (Anderhag, Emanuelsson, Wickman, and Hamza 2013) we therefore used population data to make evident what statistical associations there are between important background variables such as parental educational level and household income and the students’ choice of applying for post-compulsory science. This data was used to locate compulsory schools in Sweden where more students than expected, considering their home background, chose the Natural Science Program in upper secondary school. In schools
deviating positively, we assumed, teaching in science may compensate for experiences related to home background. Here teaching in science may make a difference.

We were thus primarily interested in how teaching may support students’ interest and the feature article was the next step towards studying this, namely by developing a methodology to study how cognition, norms, and values is simultaneously transacted and made continuous in classroom action (i.e. constitution of taste). The taste analysis was then used to examine how a teacher located through the quantitative study supported his students’ interest in science (Anderhag, Hamza, and Wickman submitted). Our research agenda is thus grounded in teaching and therefore our focus has not been so much on student habitus and social fields, but rather the consequences teaching may have for changed student action in the science classroom.

Obviously student habitus and social fields are intertwined with teaching and learning, and our research is also motivated by the assumption that teaching can make a difference to students’ lives. Human dispositions are durable but not eternal (Bourdieu and Wacquant 1992). However, at the same time as students’ distinctions of taste reflect habitus and consequently dispositions embodied through their upbringing, teachers can do little about their students’ socioeconomic background. Through their teaching, however, they can make an important difference for the student’s capability to participate in science, experiencing science class as meaningful and science as one possible option to consider for future career. Also long term studies of changes in habits or habitus are needed.

These studies are of course not enough for making any final judgments regarding taste for science and more empirical examinations are needed. Considering that our research primarily has focused on hands-on-activities in lower secondary science classrooms, it should be interesting to examine also how taste is distinguished in other activities, school levels, and socio-cultural contexts.

Widening the scope of the analysis

Notwithstanding what has been discussed above, the reproduction of certain social structures rather than others is a critical aspect that needs consideration, and the forum is an important contribution in regard to this. Schindel Dimick shows how the taste analysis can be incorporated particularly into Bourdieu’s field analysis and so acknowledging structures that are simultaneously operating and reproduced at the macro level and the micro level. In this way the third person perspective adapted for the last two steps of our analysis, namely where it is examined how the taste observed in classrooms is current also to other fields of science, can be extended also to inquiries about how certain structures are reproduced so as to exclude others more generally. Although teaching may be successful in changing students’ taste and interest for science in ways which are compatible with secondary and tertiary fields of science education or with science in certain fields of society, marginalized fields in relation to ethnicity, sexuality, social class or gender may still be excluded in ways which may be questioned or criticized (cf. Aikenhead 2006). For pluralistic and political reasons, a certain change of taste for science observed may not be the one we want. Schindel Dimick’s commentary thus makes an important caveat for further studies on the change of taste, to ask themselves what kind of habitus that is constituted and what structures that are reproduced also when students become interested in science. Science education is never only an empirical or rational question, it is always also about what we value.
References


**Per Anderhag** is a PhD-student at the Department of Mathematics and Science Education, Stockholm University, Sweden. His research focuses on how interest in science is constituted in classroom action.

**Per-Olof Wickman** is a Professor at the Department of Mathematics and Science Education, Stockholm University, Sweden. His main research interest is the constitution of science content and its values in social interaction.

**Karim Mikael Hamza** is senior lecturer in science education at Stockholm University. His research focuses on developing and refining didactic tools for teaching science, primarily together with practicing teachers.
Inside versus outside the science classroom: examining the positionality of two female science teachers at the boundaries of science education

Tang Wee Teo

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Abstract The third wave feminist studies in science education take the stance that science teaching is political and that social change is possible through interrogating power inequalities and decentering science to balance out power. For science educators, this means developing an awareness of positionality, which I define here as a stance undertaken by an individual as she or he recognizes and makes sense of the workings of the factors and forces that constitute the politics of her/his context. In this paper, I analyze the positionalities of a female Hispanic American and a female Chinese Singaporean science teacher that influenced the ways in which they interacted with students in the consensual process of science meaning making and relationship building in and outside the classroom. The findings drawn from the analysis of the teachers’ transcribed interviews and written reflections show that their personal histories, experiences with social stereotyping and control by authority shaped their positionality. They constructed alternative curriculum spaces empowering themselves and their students to transcend perceived limitations and have voice. However, their positionality did not lead them to question the boundary they saw between the social bias and content of science education. Several implications for teacher education are discussed.

Keywords Positionality · Science curriculum making · Boundaries of science education

The third wave feminist studies in science education underscores the political nature of science teaching and argues that social change is possible through interrogating power inequalities and decentering science to balance out power. In comparison to the first wave
that emphasized external factors resulting in unequal opportunities for women, and the second wave that acknowledged that there are multiple ways of knowing and women bring different ideas into their construction of science knowledge, the third wave employs a critical lens to examine how social categories such as race, class, and gender become political forces circumscribing the role, status, and recognition of women in science (Barton 1998). A more activist stance towards changing science education to make it more equitable for all individuals is invoked in the third wave. A manifestation of this stance is the emergence of a new discourse in the science education literature that draws upon ideas such as intersectionality, identity, and positionality from feminist studies and postmodern theories to deconstruct the complex structures in which women live out their experiences in science contexts. An example of such work is Heidi Carlone and Angela Johnson’s (2007) study that applies identity as an analytic lens to understand the science experiences of 15 successful women of color. The study illuminates the political nature of experiences and work of these women and the need for women’s voices to be heard in science education. However, less is known from the literature about the political work that science teachers’ do in and outside the classroom, what they think about the their work, and how they establish relationships with students.

In my view, undertaking a political stance means to enact positionality upon recognizing and making sense of the workings of the factors and forces that constitute the politics of a context. The stance or disposition that a teacher undertakes is a result of making sense and selecting the significant elements (e.g., family and social views, personal values, and beliefs) that matter to herself or himself, integrating them into her or his existing knowledge, belief and value systems, and applying these ideas to address a situation. For example, a teacher finds out that a group of students in her or his class have parents who take on several part-time jobs and hence, it is likely that they do not receive parental guidance at home. On observing that these students tend to lag behind in their schoolwork, this teacher decides to offer afterschool consultation to students hoping that she or he can play the role of a mentor or guide. Thus, she or he may be seen as taking a political stance so that all her or his students have equitable access to resources in education. I perceive the process of identifying and constructing one’s positionality as a dialectical one involving a conscious and unconscious mentation that draws upon symbolic (e.g., gesture, tone, body language) and enactive (e.g., articulated words, action) representations to negotiate the relationship with self and others, and a physical and expressive self. At the same time, the individual can employ her or his positionality to manipulate the symbolic and enactive representations and hence, experience. In the context of science education, positionality shapes how teachers think about the purpose, role, and significance of science to themselves and their students.

In this paper, I analyze the positionalities of a female Hispanic American and a female Chinese Singaporean science teacher that influence the ways in which they interact with students in the consensual process of science meaning making and relationship building in and outside the classroom. I refer to this process as *curriculum*—the host and trajectory of experiences created in an intersectional space where class, race, gender, and ethnicity interplay in the construction of stance, identity, knowledge, relationships, values, dispositions, and actions. As such, the experiences in private and public domains such as home, classroom, school, church, and social clubs constitute the curriculum of an individual. By *curriculum making* I mean the provision of in-class and out-of-class opportunities for creating experiences that allow for the construction of positionality, knowledge, relationships, values, dispositions, and actions. For example, a science teacher can consciously integrate elements of the home culture into the teaching of science so that students can
understand how abstract science concepts may be applied to understand how things work in their everyday lives rather than accept science knowledge as a set of objective facts. By consciously reducing the notion of “difference” in boundary spaces such as the society, family, social group, school, and classroom students can participate actively in learning across multiple settings. In my earlier paper (Teo 2013), I have described curriculum making as performativity, or expressed embodiments of knowledge about ways to manage tensions, contradictions, different understandings, and relationships. This view of curriculum making allows for the understanding of teaching as a complex, politicized act. However, such efforts in curriculum making may not always be consistently applied by the individual across contexts, or appreciated and understood by others who do not share a common political ideal.

Purpose of this paper

In this paper, I present case stories of two female science teachers, Rosa and Li-Lin (pseudonyms are used in this paper), from different parts of the world. Rosa introduced herself to me as a Hispanic Latina from Puerto Rico. Her self-description alluded to the political positionality she embodied that gradually became clearer to me as we talked. She had a doctoral degree in Chemistry from a US university. She was married with two teenage children and taught Chemistry in a US specialized science school for gifted science students. Li-Lin was a Chinese (which forms the majority race) Singaporean. She had a Bachelor of Science (Biology) degree and a postgraduate diploma in teaching, which certified her to teach in Singapore public schools. Both teachers enacted positionalities informed by the social and cultural contexts from which they operated and lived out their lives. Interestingly, even as they offered attention and extended their help to students—who like themselves did not receive equitable support and treatment by others—outside the classroom, they did not see a need for the same kind of social valuing in their science teaching. They hoped to develop students’ interest in science but taught science as if it was values-free and emphasized heavily on teaching of science content in their lessons.

In this paper, I show that even as the two women enacted their positionality, were aware of social biases, and motivated to provide support to students who experienced discrimination in school, they failed to interrogate the imbalance of power dynamics of science classrooms and the values-driven nature of science, so that students might participate fully in science learning. This implies that politicizing positionality in one circumstance does not necessarily translate into a visible and different politicized model of science education for learners from diverse backgrounds and that the relational spaces female teachers occupy in science education may reproduce the power dynamics actively found within a society. This could challenge efforts to provide a more inclusive form of science education that underscores the importance of valuing the reflexive relationships between self, science, schools, power, knowledge, and the social, political, and historical dimensions of experience in curriculum making (Barton 1998). It is, however, not my purpose here to describe what an “inclusive science” lesson looks like because the positionality of teachers may be enacted differently depending on many factors including their assessment of the situation and concerns they have over certain issues. Rather, this paper contributes to the literature by providing cautionary notes for teachers and researchers not to: (1) draw boundaries between what is done in and outside the classroom, and (2) view science learning and teaching as different from social experience, relationships, and context.
The main questions that guided my inquiry into the two teachers’ positionalities and curriculum making are:

1. What were the different forms of positionality emergent from the personal and professional curriculum of Rosa and Li-Lin and how were their positionalities constructed by them?
2. How did Rosa and Li-Lin enact their positionality and how did others receive it?

The teachers’ curriculum and the curriculum they created with students were integral to my analysis of their positionality. I interrogated the complexities of positionalities undergirding the teachers’ knowledge, deep-seated intentions, interactions, and identities in science teaching. In what follows, I describe my views about positionality synthesized from my own experience and reading of positionality literature in and outside of science education. Then, I provide a brief description of the two broader sociocultural and sociopolitical contexts of the two women’s curriculum in which their positionalities were embedded. This is followed by more specific descriptions of the US and Singapore education contexts and the individual teacher’s school contexts. Following this, I present the methods of the research design. Then I provide separate narratives of the two teachers to illuminate their positionality and how they maintained the grand narrative of science. Finally I conclude with a discussion of the implications for teacher education.

My understanding of positionality

Positionality is a latent force and becomes apparent to self and others when an outward action is expressed to show the political stance of an individual or group. Drawing on my own first experience teaching an inaugural lesson on gender issues in science education in my Masters class in Singapore, I will illustrate what I mean by positionality.

A male teacher in that class initially claimed that there was no gender bias in science teaching. According to him, he had taught for many years in school and saw no difference in male and female students’ academic performance in science. A female teacher in the same class concurred with him and both of them expressed that gender did not matter in science teaching. Their positionality in science teaching—that is, science is gender-neutral—is a common one. Science, as it is currently taught in most classrooms around the world, involves the transmission of science content or propositional knowledge that is rooted in androcentric and Eurocentric origins (Keller 1985). Scientific knowledge contains factual information and hence, it is depicted as apolitical and gender-neutral. The science classroom discourse, constitutive of “non-negotiable hard truths”, allude to the nature of the two teachers’ science classroom discourse with students.

I want to add that their positionality shifted by the end of the lesson as more examples of how science may not be gender-neutral were discussed, reflecting the dynamism of the positionality which changed over time. The course readings I gave incited the teachers to think about the claims presented in articles based upon studies done in the US where gender issues are openly discussed. It made them think about the validity of the claims if they were made about Singapore science classrooms where issues of gendered science are seldom (if ever) talked about. This shows that positionality is a dynamic “shifting locus” or a locale found within a complex matrix of factors and forces existent and interplaying within in a situated context and that are relevant to the issue on the table. This dynamism, as Barton (1998) argues, can be constructive as it allows people “to denaturalize” and “embrace change” (p. 29). This brings me to my next point.
To enact positionality is not to simply act out a line of action using symbols and self-indications in shared action with other social actors (Teo and Osborne 2012). Rather, it invokes larger political struggles when one is confronted with tensions, conflicts, and contradictions so as to make change. To do this, one must recognize the relational boundaries of class, race, gender, and other social categories or location within a context of interest or immediate relevance.

Understanding about positionality allows people to problematize the fixed nature of identity and abandon binary thinking in feminism and multiculturalism debates (Anthias 2002). For example, imagine a group of people dialoguing about the term “gender”. Some of them associate the word with biological differences while others argue that it is a socially constructed notion. Hence, the word “gender” is no longer a static notion but a social and political issue open to debate and contestation. Nonetheless, when individuals make a stance on their views about gender, they are also making known their positionality to others. This may result in them self-categorizing and being categorized by others as a certain kind of people. Like symbolic markers such as language, skin color, and accent others may deploy positionality in self-attribution and attribution. This is precisely what happened to the two teachers in this paper who saw themselves as different from others.

**Sociocultural and sociopolitical context of the teachers’ curriculum**

Common in the social contexts of the two teachers examined in this study is the belief that greater social mobility can be gained through attaining meritorious academic achievement, particularly in science, technology, engineering, and mathematics (STEM) fields; advancements in science and technology developments is key to the national security and economic development of the two countries. But there are differences in the context. In the US, the call for increase in the representation of women in STEM fields through pursuing post-secondary degree and a career in STEM fields is strong and explicit. The same or similar kind of rhetoric is, however, not explicit in Singapore even though there are noticeably fewer women in engineering and physics courses at the universities. In a study conducted by Pey-Tee Oon and R. Subramaniam (2013) on 1,076 secondary school (Grades 9–11) and junior college (Grades 11–12) students of approximately equal gender ratio, they found no significant differences in the way Singapore male and female students view the difficulty of physics and factors influencing their choice of physics as a subject of study at tertiary levels. I read this as indicating that Singapore students hold the earlier idea that science is gender-neutral and it does form a significant factor shaping certain outcomes of science education.

**US education and Rosa’s school context**

In the United States, education is mainly provided by the public sector and funding comes from the local, state, and federal levels. Students generally enroll in public schools located in the local school district where they live or they can choose to study at private schools. Public US schools include public, charter, and magnet schools. Private schools can be single-sex, religious, and secular schools. Public schools are generally required to meet the adequate yearly progress (AYP) mandated by the No Child Left Behind Act signed into law in 2002, but the state governments decide on the educational standards and standardized testing. Typically, elementary education is provided at Grades 1–5, secondary education is
provided from Grades 6–8, and secondary/high school education is provided from Grades 9–12.

Rosa teaches at ASTEM, a specialized US STEM school established less than 30 years ago. ASTEM is publicly funded but it is different from most public schools as it provides compulsory boarding, tuition-free education that specializes in STEM curriculum catered for the gifted and academically talented students. As such, the school is not held accountable through standardized measures and students do not take the state tests at all. Historically, opposition by stakeholders in the local school district has resulted in the school being funded by the state instead of locally. Charged to nurture the talented and gifted learners from across the state, this school accepts students beyond its local school district including minority students who show potential but were previously disadvantaged in educational opportunities. Hence, a group of minorities are recruited separately while the majority is admitted based upon their former secondary school academic results, student essays, and recommendation letters.

Due to ASTEM’s location to nearby national research facilities that houses many foreign scientists, especially from China, the school has a relatively high population of Asian American students. In 2009–2010, the student demographics (Grades 10–12) consisted of 51.5 % male and 48.5 % female—40.5 % White or Non-Hispanics, 40.8 % Asian/Pacific Islander, 8.3 % African American, 5.3 % Hispanic/Latino, 2.5 % Multiracial; and 2.5 % Other ethnicities (ASTEM Quick Facts brochure, October 2009). All the teachers had a minimum of Master’s degree, 52 % hold doctoral degrees, and 23 % are certified by the National Board of Professional Teaching Standards.

Singapore education and Li-Lin’s school context

In Singapore, the majority of schools are public and others may be government-aided (i.e., partially funded by the government), independent (i.e., more autonomy in the school curriculum design and administration), and specialized (i.e., offers a curriculum specializing in the arts, sports, or science and mathematics). Almost all schools are managed or overseen by the Ministry of Education that also provides the school funding. Primary (equivalent to Grades 1–6) education is compulsory and students are admitted in phases based upon different conditions such as having siblings in the school, parents who are alumni members or school staff member, and parents who have volunteered services at the school. Based upon students’ academic performance at Grade 6 and/or school affiliation, they will be admitted into secondary schools (Grades 7–10 or 11) and academically tracked according to the duration of secondary education, degree of content coverage, type of national examinations to be taken, degree attained, and access to post-secondary institutions. For example, students placed on the Express and Normal Tracks will attend 4 and 5 years of secondary education respectively.

Li-Lin, taught at United Girls’ Secondary School (UGSS, a pseudonym), which was a government-aided religious missionary all-girls school with more than 70 years of history in Singapore. Students were admitted based upon their Grade 6 national Primary School Leaving Examination scores, school affiliations, and talent in the schools’ niche sport. Based upon students’ results at the GCE O-level examinations in previous years, the school was considered a middle-tier secondary school. Although the student demographic details were unknown and confidential, the majority of the girls were Chinese and the minority included Malays, Indians, Eurasians, and others—this reflected the racial demographics in Singapore. Approximately 78 % of the full-time and part-time teaching staff were female.
Methods of the study

Rosa and Li-Lin were research participants in two separate studies. Both of them were raised in poverty, worked hard to earn a science degree, and found a science teaching job. They shared a critical awareness and eye to the restraining factors and forces in their societies and institutions. They spoke and wrote critically about the unequal power structures in school and how they had reacted in ways that may be regarded as controversial by colleagues. The stories they shared with me showed how they interrogated the dominant practices and worldviews in their respective contexts, and enacted pedagogies different from their colleagues to manage tensions. None of the other teacher research participant demonstrated the similar kind of politicized positionality they expressed. Hence, they represent unique, intrinsically interesting, and revelatory cases (Stake 1995) offering new perspectives on how women in science teaching deal with issues of marginalization and authoritative control experienced by themselves and some students in their school.

Using two different approaches—interviews and written reflections—I invited Rosa and Li-Lin to tell me stories. In this way, they (as narrators) took responsibility for making the relevance of the story clear (Polanyi 1985, p. 13) to me so that as an “outsider” I could empathize with them and provide interpretations of their narratives. The verisimilitude of these narratives enhanced the degree of believability and hence, the validity of the stories told.

Data collection

The data reported here were collected from two in-depth interviews (total of 88-min) with Rosa and three written reflections from Li-Lin. In the first interview with Rosa, I asked her to describe herself, tell me about her experience teaching at ASTEM, and her relationships with colleagues, students, and parents. During the interview, Rosa intended to broach the topic of minority and/or girls and her empathy for them. In my second interview, I asked Rosa about the social club which I overheard an African American and a South Asian American girl talking about. Rosa talked about it at length underscoring the stereotyping issues that in particular, minority girls, confront in the school.

I was acquainted with Li-Lin through a collaborative project with a science education researcher located in Singapore when I was still studying in the United States. We had tasked her to write about her general and science curriculum work, and reflective practice. The three questions or prompts asked were: (a) Describe your experience in science curriculum making and teaching, (b) What are some factors you consider in reflecting on the curriculum and teaching? (c) How are these factors important or significant? She wrote her narrative which was revised twice.

In Li-Lin’s first written narrative, she critically examined her own curriculum making which changed over the years. She mentioned observing differences in students’ learning abilities and family backgrounds but did not elaborate on them. In my written response to Li-Lin’s narrative, I asked her to provide examples of her experiences with these students and how they responded to her. I also asked if she noticed differences in relation to gender, race, and ethnicity and how she worked with these differences. In her second narrative, Li-Lin wrote that she had not notice many differences between girls and boys. I was unsuccessful in my subsequent attempts to elicit further insights on these issues. Several months later, I initiated Li-Lin’s entry into a critical discourse by inviting her to read a fiction story titled Snow Brown and the Seven Detergents: A Metanarrative on Science and...
the Scientific Method written by Banu Subramaniam (2000). This short story was about a brown-skinned girl from the Orient who wanted to leave her hometown to become a scientist. In her pursuit to be successful in the “Department of the Pursuit of Scientific Truth”, and live up to the expectation of the White Patriarchs, she decided to use seven detergents to remove her name, accent, “third world mentality” (laziness), emotions, subjectivity, over-confidence, and brownness. In the end, she lost her self-identity and still did not succeed because she was too beautiful to be a scientist. The story was given to Li-Lin to provoke her critical reflections about science—that it was not a-social and a-cultural. She shared a story about how she had been “silenced” in school and raised her class-consciousness—these were not mentioned in her earlier narratives.

Validity

The interviews and written reflections contain rich information revealing the teachers’ feelings and thoughts and personal stories that, to me, were insightful and challenging taken-for-granted assumptions that many educators make in their everyday speech and actions. Their personal stories illuminate their positionality and curriculum making to generate a more complex and deeper understanding of who they are, what they do, what they think about, and why they write, speak, and act in certain ways. This understanding contributes to the rhizomatic validity (Lather 1986) of the study as paradoxical objects are produced when moved away from hierarchies to networks of understanding about the complex construct of positionality. The validity of this study was also achieved with the help of the two teachers. Through selecting and constructing their narratives during the interviews and reflection writing, they helped me to understand them. For example, Rosa told me that she did not write well in English and asked me if I was bilingual. She probably wanted me to empathize with her difficulty in writing using a second language. She helped me to understand why her sponsorship of the all-girls social club was important. In explaining to me why she was specifically working with the Hispanic students she said, “See, you’re from a different culture. You’re from a culture where everybody expects you to be smart. I’m from a different culture that people expects me to be dumb” (Rosa, interview, September 17, 2009). Her daughter also experienced discrimination in school. She added, “My daughter is in high school and trying to get her to raise to an honors class was a nightmare because people assume that I’m dumb especially because I have an accent” (Rosa, interview, September 17, 2009). In telling me about her daughter’s experience with stereotyping she was helping me to understand the issues minority women in science share. This information provided added understanding about the construction of her positionality.

Data analysis

I used the constant comparative analysis approach (Glaser 1965) to organize, code, and interpret the data because the underpinning factors and forces characterizing ways of thinking, living, and acting can often be overlooked while examining familiar contexts and self. I analyzed each case, and, then I did a comparative analysis of the two teachers. Comparative analysis requires the cases compared to be commensurable but not necessarily identical (Pickvance 2001). The commensurability of the two teachers lay in their “difference” (i.e., outlier status) which provided a platform for theorizing about their curriculum making in terms of the positionality they embodied. They were compared with one another as I sought to appreciate the complexity and peculiarities of each case (Tilly...
1984). Their similarities and differences were constructed rather than observed in the process. In my separate encounters and working relationships with the teachers, I was aware of the overlapping, complementary, and contrasting experiences, ideas, and actions that these two individuals had even though they lived completely different lives and in different parts of the world.

I analyzed the data by coding the two sets of data separately—first by re-reading, re-coding as I interpreted the data (Creswell 2009). I coded Rosa’s interview transcripts using codes that I identified as I read them. Each time a new code was identified, I reexamined the transcripts and coded them using the new codes. Then I read Li-Lin’s reflective narratives and coded them using the same set of codes. When new codes were identified, I returned to Rosa’s transcripts and coded them again.

Prescriptive and emergent codes were used to analyze the data and the codes were subsequently grouped into categories. For example, the prescriptive codes—relational, political, dynamic, ascribed, enforced, and selective—refer to the forms of positionality reported in previous literature. Additionally, I also identified another form of positionality—paradoxical—that was emergent from the data and not reported in previous studies. These codes were categorized under “forms of positionality that played out in the curriculum”. As the codes became integrated into categories, I reduced them further into themes for parsimony and to facilitate the generation of theory about positionality and curriculum work, and present them in the discussion following the two narratives that I show below.

Rosa’s narrative

Rosa personal history and experience

Rosa described herself as a Hispanic woman and a member of the Latina community who originally came from Puerto Rico and spoke with an identifiable accent. She was a mother of a teenage boy and girl. While studying in college in Puerto Rico, she experienced an abusive relationship but eventually found courage to get out of it by telling herself that she was ready to become a professional. Subsequently, Rosa traveled to the United States and pursued a doctoral degree in chemistry at a large public university in the Midwest. Her first teaching job was at a community college, also in the Midwest. To sustain her finances while carrying her second child, she taught part-time. Later, she taught full-time at a bilingual middle school where she was the only teacher with a science degree. Rosa was told to teach science and reading when the school did not have money to hire a trained English teacher. However, she did not feel competent teaching reading. She resigned to pursue a master’s degree in teaching for 1 year and subsequently student-taught at ASTEM. When she applied for a position at ASTEM, they wanted to engage her as non-teaching staff doing grant writing for the schools’ outreach wing. She turned down the job offer as she had wanted to teach. Subsequently, they hired her a week before the school term began as a teacher had left the school. She was hired as a full-time chemistry teacher at ASTEM and had taught there for 8 years (Rosa, interview, May 21, 2010).

Through her interactions with people in and outside ASTEM, Rosa came to realize the resiliency and pervasiveness of social stereotyping expressed through symbols of institutional structures. Her repeated experience with stereotyping reinforced this:
When I tell people that I teach, their first assumption is that I teach Spanish. So when I tell them I teach chemistry, they go, “Really?” (...) [I] would say 90 percent of the people, 99 percent of the people would say “Really?” [said in a higher tone]. And if I said I teach at ASTEM or if I had a PhD, their eyes just like [Rosa widens her eyes], because that’s not what is expected of someone like me; because their attitude is that most people like me are, have no papers, and no education and no work ethics. (Rosa, interview, May 21, 2010).

Rosa could sense that she was stereotyped through interpreting other people’s responses, tones, and facial expressions.

Rosa and ASTEM

Rosa felt she was different from other teachers at ASTEM. Rosa said, “[I]’m a little different chemistry teacher. Well, I’m a Hispanic woman and there are very few people like me” (Rosa, interview, September 17, 2009). Having lived, studied, and worked in Puerto Rico and parts of North America, Rosa felt more world-wise and culturally-enriched. Being the only Hispanic teacher in the science and mathematics department, a photograph of her was printed in school brochures to showcase diversity and social equity. She understood its symbolic value in letting minorities and girls see that it was possible to be successful in science. Nonetheless, she was often “accused of being too easy (…), of teaching too much with my heart and not enough with my brain” (Rosa, interview, September 17, 2009). In one incident, she had to let her colleagues grade a student’s script to prove that she was not an easy and biased grader (Rosa, interview, September 17, 2009). She valued her “humanistic”, “caring”, and “approachable” qualities, but her colleagues saw her “mother-hen” (Rosa, interview, September 17, 2009) quality as giving bias treatment favoring students of color.

Rosa learned that the minority students experienced greater difficulty adapting to ASTEM than their non-minority peers. Some of them felt inferior being accepted into an elite community when their admission was through special concessions. This made her wonder if her school administrators, colleagues, and students thought the same about her. Rosa said, that some of the Hispanic students thought they were accepted into the school only because they are brown. She was concerned that other people in the school would think about her in the same way. She asked her principal, colleagues, and students who anecdotally said to her, “But no Dr Rosa. No, because you have an education” (Rosa, interview, September 17, 2009). She sought reassurance from various people and talked herself into believing that: “[I]’m different. I’m not the norm of most people. (…) I’m always very proud of who I am. And I know the kids [students] know” (Rosa, interview, May 21, 2010). Although the school administrator gave her his reassurance, she was skeptical about it. She said, “So I say, ‘Oh, good.’ So, they think they can make you the same as other people regardless of what you look like or sound like” (Rosa, interview, September 17, 2009).

Rosa established BELLAS, an all-girls social club, in her second year at ASTEM as she observed the minorities, especially minority girls, had problems adapting. She observed that many minority students felt intimidated by “overachievers”, so she created opportunities in BELLAS for the girls to be leaders—otherwise impossible in the “mainstream” (Rosa, interview, May 21, 2010)—and to feel some sense of accomplishment. She explained the purpose of BELLAS, “It [BELLAS] started 6 years ago with a group of kids who looked like me that were not very happy about being here. This place is not very
diverse to compare to [the rest of the state]” (Rosa, interview, May 21, 2010). Rosa reasoned this: “Let’s say they come from Sulia [a county in the Midwest] which is 99.9% Black. And then they come here where they have never been in a school where not everybody is Black” (Rosa, interview, May 21, 2010). In particular, she noticed that African American girls had a “harder time” at ASTEM because, “[P]eople perceive them as not being smart and they tend to dress a little sexier. And some people think that we’re [minority women and girls] just dumb and easy. It happens all the time” (Rosa, interview, September 17, 2009). Rosa could empathize with the minorities and girls in ASTEM as the school stresses hard-core content knowledge and skills historically shaped by Eurocentric/androcentric ideas (Keller 1985) not mirrored in their home cultures.

Rosa knew the importance of belonging to a stable social group formed by members whom individuals could trust and candidly share common perspectives and experiences. BELLAS was the safe space she had created to intentionally privilege (minority) girls. It offered an alternative and “safe space” for Rosa and the minority girls to retreat from alienating structures, reconstruct new relationships, and re-identify common social identities through solidarity. She said, “It’s nice to have a community where people think like you and you can kind of just decompress and talk and share ideas” (Rosa, interview, May 21, 2010). Rosa was open to sharing stories of her abusive relationship with students and colleagues to help them understand pervasive social problems minority women confront. As such, she was a symbolic figure of hope and success attainable through hard work and courage. Rosa said, “I’m one of those examples that I can do whatever I want. You just have to study, be independent and be on your own.” (Rosa, interview, May 21, 2010). In BELLAS, Rosa would talk to students about body image, eating, dating, sex, money, finances, college choice, and course selections (Rosa, interview, September 17, 2009). She would tutor the girls on Saturdays because “the girls feel really privileged at the moment of having one-to-one time” with her (Rosa, interview, May 21, 2010). She would organize school-wide BELLAS events with the girls to help the ASTEM community understand challenges women and/or minorities experienced. For example, in an event called Tales From the Home Front Rosa shared stories about her abusive past to caution and advise girls to take control of their lives. In these ways, Rosa spent a lot of outside classroom curriculum time with the girls in BELLAS. According to one of Rosa’s student who was a member of BELLAS, the members would come together to advocate women’s rights, support women’s cause like how to defend oneself physically. This student also said, “[BELLAS] helps to open up to other students too. You may not know them as well before but you have that club in common to come in” (ASTEM student interview, May 7, 2010). However, not every staff in ASTEM agreed with the purpose of BELLAS. Rosa rebutted them, saying that they asked because they did not understand what it meant to be “a woman in science” (Rosa, interview, May 21, 2010).

Rosa’s science curriculum making

Ironically, although Rosa acknowledged that race and gender discrimination existed in ASTEM, her consciousness of prevalent and persistent discriminations did not inspire transformative pedagogies involving the co-construction of knowledge with students in her science curriculum work. When I asked if she had considered gender and race issues in thinking about the chemistry curriculum, she said, “I just bring my personality and my point of view. Again I think everybody is capable of doing whatever, it doesn’t matter what is the color of the skin” (Rosa, interview, May 21, 2010). Rosa believed that hard work was the “ticket” out of discrimination, but it contradicted her own experience with
imposed stigma despite her high qualifications and professional status. She said she would be more emphatic towards minority students, but that contradicted her hard stance towards students. She said, “[I] mean we are not baby-sitters. (...) If you [students] don’t do it, it’s your problem, it’s not ours” (Rosa, interview, September 17, 2009). She was insistent on this view as she reiterated in the second interview, “[I] don’t think that I treat my students different[ly] because they are from different races. So it’s about working hard (...) I’ve been there and I’ve done that. (Rosa, interview, May 21, 2010). But, most of her minority students had arrived at ASTEM disadvantaged with respect to their prior learning. Ironically, her steadfast belief in meritocracy had led to her insensitivity towards racism, classism, and her students’ disadvantages.

Li-Lin’s narrative

Li-Lin’s personal history and experience

Li-Lin had 9 years of teaching experience at two secondary schools for Grades 7–11 students (Li-Lin, reflective narrative, 24 July, 2010). Although Li-Lin belonged to the majority race in Singapore, Li-Lin felt she could relate to students with diverse racial backgrounds and social class as she came from a working class family and had friends from diverse backgrounds (Li-Lin, reflective narrative, December 14, 2010).

When Li-Lin was younger, she had lived in two extremely different home settings. Li-Lin described her family background as “low class” and her parents are “uneducated” (Li-Lin, reflective narrative, December 14, 2010). Her mother had worked as a housekeeper in a British colonial home, and as a road sweeper in the military air base. Her father was an odd-job electrician who had learned the skill on the job. During the school year, Li-Lin would live in her paternal uncle’s house. During the school holidays, Li-Lin would return to her parents’ rented room at the military air base. As she shuttled between two home settings—a “luxury air-conditioning” “landed property” versus an “old, dusty, mosquito-infested, and cramped” room (Li-Lin, reflective narrative, December 14, 2010)—Li-Lin became deeply aware of how poor her parents were. Nonetheless, her uncle’s wife had taught her to respect her parents regardless of their wealth. As such, Li-Lin felt that “class never existed with me” (Li-Lin, reflective narrative, December 14, 2010) given her knowledge of her parents’ financial status. She felt fortunate to have “double dose of real parenting” (Li-Lin, reflective narrative, December 14, 2010). Her brother did not receive a college education but underwent vocational training. She explained, “So because of my upbringing and circumstance, class and race and intelligence never got in the way of my expectations of my students” (Li-Lin, reflective narrative, December 14, 2010).

Li-Lin and UGSS

Li-Lin had experienced tension with her school. She recounted an incident at a school meeting where the Principal expressed her expectations of teachers and students achieving high standards:

When I asked the question [about what was meant by “high” standards], and my Principal threw it back at me, I did not feel any embarrassment. However only after the HOD [Head of Department] chided me, then did I feel embarrassed about it. Ever

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since then, I have always kept my mouth shut and only voiced something when I thought about it many times over. (Li-Lin, reflective narrative, December 14, 2010)

Li-Lin was vocal at UGSS until she was “told off” by a Head of Department (HOD) for a rhetorical question she asked the principal, making her “feel stupid”. She said, “I suppose that chiding remark was some sort of ‘detergent’” (Li-Lin, reflective narrative, December 14, 2010), meaning that it had eradicated her rights and courage to voice out.

Li-Lin did not totally adhere to the school’s way of disciplining students. Rather than taking the punitive approach when students broke rules, she would resort to using “emotional blackmails” such as telling them they would “break her heart” or request for them to “give me some face” — a common cultural phrase which she and her students understood as showing respect and compliance. She reasoned this: “I feel that the relationship with the child is the most important so you can motivate them not to do well for themselves but to do well for you” and the problem becomes “permanently solved” (Li-Lin, reflective narrative, December 14, 2010).

Li-Lin believed that rapport building with students was important as it could reap longer term benefits in terms of managing students’ behaviors and attitudes.

She made efforts to establish relationships with her students. She said, “I remember an Indian girl in my class said to me once ‘Cher [vernacular for ‘teacher’], you are a good teacher because you don’t just talk to the Chinese girls. You come and talk to us also’” (Li-Lin, reflective narrative, December 14, 2010). Below was a reflective narrative Li-Lin wrote to describe her experience with a handicapped girl, Anissa, which also attests to the positive relationships she had developed over time with students:

[Anissa] was notorious for being pesky and annoying. She had vision impairment and wore coke-bottle glasses. She was attention seeking because she knew she had good ideas and tried to make herself heard. But the more she tried, the more people brushed her off. (...) [W]henever she came to talk to me I was indifferent and spoke to her in an uninterested tone. Then one day a very good friend who also taught my class came to me to discuss about my girls and, of course, Anissa. She said to me: “Anissa is actually very interesting to talk to if you give her chance [sic]”. (...) With that comment, the next time Anissa came to talk to me, everything changed. The girl was really interesting to interact with and our relationship blossomed to a point where I could tell her point blank when she became pesky at times and she would back-off. Slowly I started to correct her behavior and how to deal with her classmates bullying her and build her self-esteem. (...) As time progressed and she improved in her EQ [emotional quotient], I began to respect her very much as a young person because she was self-assured enough to make fun of her own disability. There was once I wrote an instruction on the board and like the other kids she just ignored it. I asked her rhetorically, “Why you never see?!?” She flatly replied, “Because I am blind”, I just crumbled into laughter and so did she and her friends. Even though Anissa is in JC [junior college] I [equivalent to U.S. grade 11] now, she still has the heart to call me and ask, “Hey, how’s life, man?” and we would chat until she reaches home and her mother starts nagging at her. (Li-Lin, reflective narrative, December 14, 2010)

Li-Lin’s relationship with Anissa was one example of the close teacher–student relationship she had developed with a student. Anissa’s response “Because I am blind what” was spoken in non-standard English, but it was cultural and evocative of the close
relationship she had developed with Li-Lin. Li-Lin saw the positive and moldable qualities of students’ character. This was premised on her belief that students’ differences were not always about ability but motivation and were responsive to proper guidance (Li-Lin, reflective narrative, July 28, 2010)—Li-Lin was willing to play this role.

Li-Lin’s science curriculum making

Li-Lin talked about ethics issues in her science lessons. She would tell students to “appreciate nature,” “don’t kill something just because you can’t stand the sight of it,” “take care of your health,” “don’t eat bluefin tuna because it’s not sustainable” (Li-Lin, reflective narrative, July 24, 2010). Her goal was to inspire students’ curiosity in the natural world, learn about how organisms survive, respect every organism’s right to live. She wanted them to “develop empathy for all beings” as she had read a quote: “How gracious a country is, is how its people treat their disadvantaged and their animals” (Li-Lin, reflective narrative, July 28, 2010). She was less concerned about students learning the content than getting them to be interested in learning science. She noticed that students liked to listen to stories of their teachers’ lives so she would share stories about her uncle “who had smoker’s cough until he burst blood vessels in his lungs and started vomiting blood” (Li-Lin, reflective narrative, July 24, 2010) and link this to biology. Nonetheless, she and Rosa thought similarly that gender, race, and class did not interplay with science learning—this was the a-sociocultural positionality they had undertaken. Li-Lin professed, “I don’t notice many differences with girls. I think most girls regardless of race and ethnicity will fall into the same problems” (Li-Lin, reflective narrative, July 28, 2010).

Discussion

Political positionalities are shaped by restraining and inequitable structures

Rosa and Li-Lin embodied and enacted several forms of positionality—raced, classed, gendered, relational, dynamic, ascribed, enforced, and selective—and they were politicized in nature because they were all connected to issues of power, privilege, access, and ideologies of science. Restraining structures including stereotyping, institutional hierarchy framed by normative social and cultural viewpoints, and inequitable structures causing disparities between privilege and disadvantage; poverty and wealth shapes their political positionalities. Both of them stood out among their colleagues and their community as they represented the “outliers”.

Self-identified as a Hispanic Latina, Rosa had to confront race, gender, and class discriminations which had the effect of detracting from her professional image. It made her consciously aware of her suppressed position in the social and institutional structure. Rosa was proud to be a minority woman in science with a doctorate but felt marginalized when she encountered people who challenged capability to teach science. In ASTEM, her ability to teach science was questioned by colleagues. Her relational positionality was complex as she yearned to be accepted into a scientific community that historically did not include women and minorities, and was simultaneously attached to an ascribed social stigma (Goffman 1963) that was difficult to divorce from. Rosa had apparently gained entry but not entrée (Brewer, von Hippel, and Gooden 1999) into ASTEM. This meant that she had to socialize into the cultures, norms, and expectations of the STEM community but was not necessarily able to integrate into it. The insinuations expressed through symbolic
expressions, voice tones, words, gazes, and language revealed doubts around her qualifications “[B]ecause usually people like me don’t go into the sciences. It’s a stereotype” and “I’m from a culture that people expect me to be dumb” (Rosa, interview, May 21, 2010). As such, she had difficulty gaining full membership in the broader STEM community. Rosa’s enforced positionality—that she could not possibly be a STEM professional—reflected her marginality at a juncture where her cultural and professional identities simply did not meet.

Nonetheless, Rosa’s enforced positionality was evocative of her political (raced, gendered, and classed) positionality. Her positionality—shaped by her previous situation, culture, personality, and success through hard work—constituted her site of politics or locus of tensions where taken-for-granted assumptions are interrogated and efforts in transformative curriculum projects were expended. I think inherently, Rosa was cognizant that the STEM curriculum-as-provided to all students was the same but the curriculum-as-experienced by the minority girls was different from their peers’ experience as their social positions limited their access to resources needed to assimilate into the STEM community. That was why she established BELLAS, which was originally intended for minority (Hispanics and African Americans) girls, and subsequently included non-minority girls who sought membership. She invested her personal time outside class and on weekends to support the girls so that they could catch up with their peers. This reflected how her relational and political positionality had shaped her outside classroom curriculum making which forms a social action addressing sociocultural issues minority girls confront in a STEM school.

Li-Lin’s political positionality was shaped by the experience with chiding described earlier and a pervasive culture of not questioning authority as a student or teacher. In response to the episode, she had learned to lie low and stay out of trouble. This had possibly influenced the way she managed students’ behaviour. Instead of blowing the issue out of proportion she negotiated with her students by asking them to give her “face”. Her resistance to the use of authority and conformity to rules revealed her political positionality to denaturalize hegemonic practices in schools that were used to control students and teachers without opportunities for negotiations and alternatives. However, based upon the Singapore and Chinese context, Li-Lin’s asking for “face” is likely to have a different interpretation. To “give face” is not simply to show politeness; “face” was a symbol of social status (Mao 1994) she used to impose authority over students making them act out lines of actions coherent with her expectations (Teo and Osborne 2012). She exercised her control over students and did not open any room for negotiations or alternative actions. She did not like being put down by authority but used her position as a teacher to ask for students’ compliance. Additionally, Li-Lin had somewhat participated in the marginalization of her new colleagues when she warned them to not ask questions. The change of positionality illuminated the complex networks of relationships, time, and context.

The above example also alludes to a form of positionality which I will term as paradoxical positionality as it emerges from either consciously or unconsciously imposing upon others the same set of structures that have resulted in the formation of the politicized position. Li-Lin might not be aware that she had created a similar kind of social hierarchy, which she did not favour, in her classroom. She had also participated in the “silencing” of her colleagues which she did not like. She might realize this paradox upon critical reflection. As James Baldwin (1988) said, “One of the paradoxes of education [is] that precisely at the point when you begin to develop a conscience, you must find yourself at war with your society” (p. 11). This critical consciousness could have an effect on her positionality and curriculum making.
Fundamentally, Rosa and Li-Lin wanted to relate to students as people. However, the political project and curriculum work were possible, in part, through imbalanced power brokering between teachers and students. In Li-Lin’s case, she had a good relationship with Anissa but their relationship was not equal as she intended to “correct” Anissa’s behaviour to reduce her social alienation. BELLAS was possible as Rosa exercised her institutional authority to sponsor the club and defend its cause even when challenged by others who questioned its inclusiveness. At the same time, their collective positionality identified through BELLAS inevitably marginalized other groups such as minority boys who may also have been previously disadvantaged in their learning and have problems adapting to the new environment.

In summary, Rosa voiced out her insecurities to better define and clarify her positionality in ASTEM and the larger social context, while Li-Lin “de-voiced” her viewpoints to keep out of the authoritative radar. Similar to the three African American secondary school teachers’ positionality examined by Felicia Moore (2008), the positionality Rosa, and Li-Lin constructed had dynamically changed with personal transitions, shifts, and transformations (Orner 1992). The diversity in Rosa’s and Li-Lin’s views and actions were not unusual as interpretations of the world depended on the circumstances of class, gender, race, politics, sexual orientation, identified space, and constructed social relationships. According to Henry Giroux (1992), there will be systems that influence judgments and choices when confronted with ideologies, values, and experiences of “otherness” different from one’s own. In fact, “It is these shifting relations of knowing and identity that frame our different modes of response to the other” (p. 3). In acknowledging their differences and engaging them politically by creating alternative spaces and establishing relationships with students to break social barriers, Rosa and Li-Lin found ways to relate to diverse groups of students in a non-oppressive manner. This reflected their decisions based upon their positionality.

Political positionality are not always welcomed in schools

According to Seymour Sarason (1996), schools are political instruments because the structure, decision-making processes, and social relationships are shaped by unequally distributed powers. An unequal society where school policies, school curricula, teaching practices, and evaluative practices are historically linked and presumed to conform to the economic needs of the powerful and dominant group is common. As such, “positional identities involve systems of interlocking oppression, privilege, and power that are experienced simultaneously and have a cumulative effect on teachers and the meanings they give to their lived experiences” (Barton 1998, p. 700). These constitutive elements of positional identities are played out in Rosa’s and Li-Lin’s articulation of “difference”.

Rosa and Li-Lin had the experience of verbally expressing their uncertainties and seeking clarifications on their doubts. Rosa’s and Li-Lin’s use of and purpose in exercising voice reflected their positionality which was dynamically shaped by contextual circumstances in association with their cultural and social identities, and hierarchical status. They were cognizant about the “difference” other people saw in them and enacted their positionality in political ways. But Rosa’s and Li-Lin’s positionality as a “different” kind of teacher was not always welcomed.

Rosa’s positionality, shaped by her previous situations, culture, personality, and success through hard work, constituted her site of politics or locus of tensions where taken-for-granted assumptions were interrogated and efforts in transformative curriculum projects were expended. BELLAS, which was originally intended for minority (Hispanics and
African Americans) girls, now included non-minority girls who sought membership. However, not everyone in the school understood the purpose of having a girls-exclusive club and challenged the need for one. When Rosa’s colleagues and students questioned the purpose of BELLAS, she felt that in asking the question, these people had not understood the issues women in science confront; that “As a woman in the sciences, this is not about science but as a woman in science” (Rosa, interview, May 21, 2010). She felt that they had not earned the right to ask or challenge the existence of BELLAS. Implied here was that being a woman (and minority) in science was not easy even if one showed meritorious achievements. Rosa had difficulty making people understand this in ASTEM (Rosa, interview, May 21, 2010).

Li-Lin learned from her experience at the school meeting that voicing out in such a context was not an acceptable way of relating to authoritative figures or making her inner thoughts known. She subsequently decided to manage her curriculum independently. The HOD had “silenced” Li-Lin in the same way the detergents had silenced Snow Brown in Subramaniam’s story. This “enlightening” incident made her more withdrawn as she recognized her low status in the school hierarchy. She soon learned that any actions suggesting the contestation of authority were not condoned. Consequently, she resorted to “silence” as a defence mechanism from further embarrassments. Her dynamic positionality, derived from reconstructed understandings of the school culture inscribed by continual imbalanced power relations and struggles in the larger cultural, social and political context of individual lives (Barton 1998), resulted in her taking a passive stance in school wide decisions.

Positionality demarcated by in and outside classroom

The social interactions Rosa and Li-Lin had with students extended beyond the classroom space and they engaged their positionality differently in making decisions in the out-of-classroom curriculum. To Rosa, science was probably the space for content learning and BELLAS was for addressing the girls’ emotional and social needs—the two spaces were parallel and complementary but not intersecting. The physical demarcation between in and outside classroom cut off the translation of positionality into science teaching. The quality of positionality as context-dependent is illuminated through the different stance Rosa took in and outside her science classroom. In this case, the marginal status of people shifted—the minority girls were marginalized in ASTEM, but not in BELLAS. When Rosa said that the girls could “work hard” like herself she had chose to be “color-blind” in the context of science teaching and learning. It was also possible that Rosa was not “color-blind” but consciously chose to ignore race and gender issues in her science teaching in order to focus on the science content. Similarly, Li-Lin proclaimed that though she could empathize with the story of Snow Brown and Anissa, she did not think her science teaching had anything to do with class, race, or gender.

Brief comparative analysis

The women’s narratives illuminate strong connections between the personal, political, and pedagogical. Putting the two women’s stories together has inevitably underscored differences in positionality and its possible impact on students’ lives. For example, even though Li-Lin shared personal stories in class, these were not similar to Rosa’s personal stories about her past. Rosa shared stories of her previous abusive relationship to emotionally connect with students while Li-Lin’s goal was to sensationalize the effects of smoking and
draw students’ attention. In doing this, Li-Lin had recreated social hierarchies in her classroom as she had expected her students to take her instructions, abide to the school rules, and accept transmitted negative viewpoints of smoking rather than critically inquiring the scientific evidence about smoking. Instead of celebrating Anissa’s difference, Li-Lin had resisted interactions with her until her colleague, who recognized Anissa’s good qualities, piqued her interest. Rosa, on the contrary, celebrated her own and her minority girls’ differences to make their presence in the community visible and reclaim their voices. This suggests that while individuals possess political forms of positionality, how one engages this and for what purpose may differ to a great extent. Hence, nuances in the two women’s positionality is unpacked here to show how it had effected their science curriculum making. The findings showed that the teachers’ personal histories, experiences with social stereotyping, and suppression by authority had shaped their positionality. While their positionality shaped their out-of-classroom curriculum, it had not altered their science curriculum making. Rosa expressed awareness of social stigma imputed to her gender and race categories, and Li-Lin alluded to her lower social class as the enabling factor in relating to minority students. Nonetheless, both teachers did not think that gender, race, and/or class had any relevance in their science curriculum work. Seemingly, an invisible boundary between subject-based and non-subject-based domains had limited the teachers’ ability and/or willingness to draw upon their positionality to “act otherwise” (Freire 1970) in science education. Even as they understood and experienced the effects of social biases and seek to address and provide support to students so that they do not suffer from the workings of ideologies that reproduce hegemony they still teach science as if it is a values free enterprise, maintaining clear demarcation between social bias and the content of science education.

Implications

In my analysis of Rosa and Li-Lin, I positioned them as social agents who were living out and creating curriculum in narratively different ways (Connelly and Clandinin 1988) from their colleagues. They, too, see themselves as different from them. Insights into teacher curriculum making and implications for teacher education may be drawn from the findings.

The findings show that embodying positionality do not necessarily imply knowledge of means and ways, having the ability or desire to address critical social issues in science education. It seems to me that positionality appears to be latent in decision making. The question becomes, how can teachers be supported in translating their politicized positions into their science teaching? I argue that researchers could provide a starting platform such as having teachers engage in collaborative action research as inquiry into their own practice and explicitly examine one’s positionality in and outside their science classroom. In this way, they may be able to understand what constitutes their political position in science teaching and how their views about science and approach to science teaching may have contradicted their political position. The ability to do this requires a deliberate attempt to fuse positionality, science, and out-of-classroom curriculum using the politics of difference. By this, we mean acknowledging differences and working with them to interrogate false dichotomies and propose alternative viewpoints; it is not about acknowledging differences to enable differentiation.

The implications for teacher education is that teachers may be supported in transitioning to become “border crossers” (Giroux 1992, p. 8) if they knew how to engage the politics of difference in cultural, ethnic, racial ideologies in dialogue, and develop trust and solidarity.
with their colleagues, students, and other stakeholders. This could help them develop the “third eye” (Maher and Tetreault 2001, p. 203) for understanding the workings of power and to create change. This stresses the importance of having a continuous view of space, “For if one begins with the premise that spaces have always been hierarchically interconnected, instead of naturally disconnected, then cultural and social change becomes not a matter of cultural contact and articulation but one of rethinking difference through connection” (Gupta and Ferguson 1992, p. 8; emphases in original). If the teachers understood how gender, race, and class differences are the result of inscriptions of dominant ideologies, normative institutional practice, and hierarchies and work this into their curriculum work, and present alternative viewpoints, the dichotomies may be broken down in analytic purview. This meant, for example, that Li-Lin may not confine her teaching to definitive conclusions on eating or not eating bluefin tuna, but helping students make decisions and understand what their decisions lead to. A new form of pedagogical content knowledge that incorporates the subject matter with positional pedagogies centered on gender, race, and class may then emerge. As such, using positionality as an analytic lens to critically examine the political nature of curriculum making and using it to develop pedagogies that explicitly address issues of unequal access can potentially become a step towards the teaching of science for all.

Inservice professional development providers may use “positionality” to curricularize—making it the center of their pedagogical discourse—curriculum work so that teachers learn more about themselves as they critically examine what they do. As William Ayers, Therese Quinn, David Stovall, and Libby Scheiern (2008) had argued, “Teachers have the right and responsibility to know themselves, and this autobiographical self-knowledge is a gift they can offer students, families, and communities in their charge” (p. 309). I believe that in understanding how experiences can shape positionality, one will be equipped to understand how curriculum is all of this: relational, dynamic, and political. Teachers may be invited to share personal stories about the tensions, difficulties, and challenges they experienced in and outside school before the theoretical construct of positionality is offered as a lens that affords a critical and reflexive platform for interrogating why the curriculum is shaped in a certain way and how curriculum making may be critically reflected upon to inform structural changes in practice, administration, and policy.

A new dimension of positionality is also identified in this study. This study identifies and substantiates the paradoxical quality of positionality as the social agents undertook actions that impose the same set of structures (e.g., discrimination, emphasized differences, stigma, and ideologies) that have led the forming of their political position and yet, they do not recognize or are not aware that they have participated in the reproduction of hegemony. The examples of this study show that the positionality an individual has need not always be consistent and hence, the pedagogies a teacher engaged need not always transcend contexts. The out-of-classroom curriculum structure and classroom demands shape the positionality stance and positionality-based decisions teachers undertake. This paradoxical positionality had not been explicitly discussed in previous work. Barton (1998) expressed tensions felt in making the choice to engage in feminist politics and teach in non-traditional ways in her community college classroom despite explicit requests from her department chair. Her reflective narrative exposed her inner struggles as she questioned if she could be fired or end up silencing her students rather than giving voice to them. Such paradoxical qualities of positionality are also captured in this study revealing the even more implicit qualities of positionality yet to be examined. This finding supports much previous work (see e.g., Kathleen Davis 2003) that showed how feminist, socially just curriculum reform policies and goals are difficult to attain. This study shows how positionality has an
important role in curriculum decision making that need not always be coherent but related to the contextual factors and forces a teacher perceives as relevant and important at the time of their out-of-classroom science teaching. Teachers’ prior knowledge, skills, experience, assumptions, and beliefs, all of which are constitutive of teachers’ positionality, must be examined in curriculum deliberation.

Conclusion

In this paper, I examined the positionality or stance undertaken by a female Hispanic American and a female Chinese Singaporean science teacher as they recognized and made sense of the workings of the factors and forces that constituted the politics of their individual context. Their positionality—shaped by their personal histories, experiences with social stereotyping and control by authority— influenced the ways in which they interacted with students in the consensual process of science meaning making and relationship building in and outside the classroom. They constructed alternative curriculum spaces empowering themselves and their students to transcend perceived limitations and have voice. However, their positionality did not lead them to question the boundary they saw between the social bias and content of science education.

Finally, I conclude this paper with Fig. 1 below which shows the overall relationship between the key ideas discussed in the paper.

The oval boundary delineates the sociocultural and sociopolitical context in which teachers’ curriculum work are embedded. Different representations, relationships, and the physical and expressive self exist in the curriculum. Teachers make use of them to construct their positionality, which in turn, is used to manipulate them. Teachers embody and
enact their positionality when creating learning opportunities for students in and outside the classroom. In sum, Fig. 1 shows the interrelationships between curriculum making, curriculum, and positionality in the two teachers’ science teaching.

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References


**Tang Wee Teo** is an Assistant Professor at the National Institute of Education, Natural Sciences and Science Education (Academic Group), Nanyang Technological University, Singapore. Her research focuses on equity issues in science education from a cultural and sociological lens.