

Communicating Science to Students: Investigating Professional Botanic Garden Educators' Talk during Guided School Visits

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Abstract: Botanic gardens are popular destinations for school visits to learn about plant-based science. However, little is known about teaching and learning in such settings, in particular about school visits guided by professional botanic garden educators (BGEs). The purpose of this study was to identify the pedagogical moves of the BGEs during guided school visits. More specifically, this study follows a qualitative research design, investigating six elementary school groups (7- to 11-years old) guided by three BGEs. The guided visits were videotaped and the transcripts analyzed in order to find out the patterns of the BGE and student discourse. The findings from this study indicate that although BGE-student dialogic interactions occasionally occurred, a non-interactive/authoritative communicative approach was the more common practice of the BGEs when communicating science to students. However, the components of storytelling and the use of analogies identified have a great potential for enriching the explanatory talk of the BGEs. The results of this study suggest that the dynamics of discourse during guided school visits were shaped by both the BGEs and students through the shift of power during this discourse.

Keywords: school visit, botanic garden, informal educator, discourse

Introduction

Recent research has indicated that school educational excursions to informal settings have a positive impact on students' cognitive learning, affective maturation and social development (DeWitt & Storksdieck, 2008; Rennie, 2007). As one of the most popular informal settings for organized school visits, botanic gardens are "living museums" of plants where students acquire practical biological knowledge, develop horticultural skills, learn to appreciate the natural environment and develop a sense of sustainability (Braund & Reiss, 2006). Every year, in the United Kingdom, each of the 130 or more botanic gardens throughout the country accommodate a substantial number of visiting school groups to support their study of plants and many of these are guided by professional botanic garden educators (BGEs)¹.

The most common purpose for teachers to take their students to informal science institutions is to enhance ideas within the curriculum or to provide enrichment beyond the curriculum, expecting students to learn content and increase their motivation to study science (Kisiel, 2005; Tal & Steiner, 2006). However, a growing number of studies have shown that opportunities during school visits to informal settings can be missed because educators tend to rely on tasks that have to be completed or explanations that need to be covered (DeWitt & Osborne, 2007; Tal & Morag, 2007). Moreover, it was found that many teachers lack the confidence, competence and expertise to teach students outside of the classroom (Glackin, 2007; O'Donnell, Morris, & Wilson, 2006). Regarding this point, a recent study of school visits to a museum reported that teachers prefer guided visits to non-guided ones as they do not have as good a mastery of the themes under consideration as the museum educators do (Faria & Chagas, 2013). Similarly, for school visits to botanic gardens, teachers often do not have intensive content knowledge about plants and resources

available on site. Consequently, attending BGE guided visits has become a common practice for visiting school groups although little is known about the pedagogical practices of this group of educators.

The sociocultural perspectives of learning highlight the importance of discourse during the process of knowledge construction. It is believed that children's learning and development involve a passage from social contexts to individual understanding, that is, knowledge is first encountered in interactions between people and then internalized into the learner's repertoire of understanding (Vygotsky, 1978). This process invites active participation in inquiry through tool-mediation, with these tools being either physical (e.g., a hammer) or psychological (e.g., symbols, formulas, written words) in nature. According to Vygotsky, language plays a central role in mental development and serves as the most important tool for mediation. In addition, Bakhtin's (1986) writings emphasize meaning-making through language use and a key notion for his work is that "any true understanding between humans is dialogic in nature" (Jakobsson & Davidsson, 2012, p. 13). Bakhtin's writings suggest that "true understanding occurs when speakers can effectively orient themselves with respect to one another in the broader context of a conversational exchange" (Ball, 2000, p. 232).

In relation to understanding teaching and learning in the botanic garden context, this study set out to explore how BGEs and students talk, mediate and exchange thoughts and ideas during guided visits. We were interested in the pedagogical moves of the BGEs when communicating science to their visiting school groups. Specifically, we asked the following research questions:

(1) What are the functional characteristics and patterns of BGEs' discourse during guided visits?

(2) How is science content communicated to visiting students by the BGEs?

Before presenting our own study we review the relevant literature which provided a conceptual framework that guided the current inquiry.

Conceptual Framework

Our analysis of BGEs' talk during guided school visits builds on social views of learning (Vygotsky, 1978) and on research that specifically applies sociocultural theories to talk in formal and informal learning contexts (e.g. Ash & Wells, 2006; Davidsson & Jakobsson, 2012; Mercer & Littleton, 2007), particularly the notion of dialogic teaching (Alexander, 2006; Mortimer & Scott, 2003; Nystrand, 1997; Skidmore, 2006; Wells, 1999), which is concerned with improving the quality of the process of teaching and learning through ongoing teacher-student dialogic interactions. Moreover, research has also suggested that teacher questions, storytelling and the use of analogies are important features of dialogic teaching and have great potential in supporting science communication (Aubusson, Harrison, & Ritchie, 2006; Chin, 2007; Oliveira, 2009). In the following section we review the relevant literature with the aim of devising a conceptual framework for this study.

Dialogic Teaching

Although, nowadays, students are usually no longer perceived as being mere passive recipients, but rather, active participants in constructing knowledge, some researchers have observed that teacher-centered, recitation-based and rote teaching are still prevalent in US and English classrooms (e.g., McNeill & Pimentel, 2010; Smith, Hardman, Wall, & Mroz, 2004). In such studies, the predominant discourse in these classrooms was found to involve a triadic pattern of interactions, consisting of an initiation by the teacher, followed by a response from a student, with subsequent evaluation or feedback to the student's response from the teacher. Research on the

triadic pattern of interactions has shown that speech-like instructions given by the teacher limit the opportunity for students to think, explain and generate new understandings, whereas these objectives can be achieved through dialogic teaching (Alexander, 2006). Dialogic teaching focuses on the interactions between the teacher and students and can provide a structured, extended process leading to new insights and deep knowledge and understanding and, ultimately, to better practice. Consequently, educators might be encouraged to support their learners to engage in building a continuous rapport. With regards to the language of dialogue, Cazden (2001) specifically identifies its functions as comprising the following: (a) the communication of propositional information; (b) the establishment and maintenance of social relationships; and (c) the expression of the speaker's identity and attitudes. Furthermore, she goes on to explain that the propositional, social and expressive functions of language align with how the cognitive and social dimensions of being are integrated and how an individual's identity and attitudes come to be developed.

According to Ash and Wells (2006), dialogic inquiry should be the fundamental practice for education in both formal and informal contexts. They argue that in both contexts, social interactions can promote collaborative knowledge building, mediated by artifacts and dialogue, when answers to questions are not determined in advance, and when expertise is distributed. Research on family groups in informal science settings has revealed that adults and children can genuinely explore the environment and reflect on each others' ideas when the former function as more experienced and responsible mentors rather than as authoritative teachers (Tal, 2012).

Classroom research has shown that the way in which a teacher responds to students' contributions directs the development of any discussion (Hardman, 2008; Nystrand, Wu, Gamoran, Zeiser, & Long, 2003; Wells & Arauz, 2006). Therefore, it is important that teachers are aware of the pedagogical functions of talk and how it can best be used to facilitate students' learning (Mercer & Howe, 2012). For advancing the collaborative discussion, a teacher should not act as the sole source and arbiter of knowledge, but seek to elicit different ideas while at the same time supporting students to express their contributions (Ash & Wells, 2006). Thus, teachers need to balance strategically their authoritative talk with dialogue so as to keep students actively engaged in building knowledge and expertise that can become widely distributed among the members of the class (Mercer & Howe, 2012; Scott, Mortimer, & Aguiar, 2006).

Teacher Questions

Questioning is one of the most widely used techniques in teaching and has a variety of purposes including keeping students active and attentive, seeking understanding, stimulating curiosity, diagnosing problems in learning, and so forth. A considerable body of evidence has highlighted how the type of teacher question affects student participation and learning. For example, Chin (2007) points out that teachers in traditional classrooms tend to ask closed questions with predetermined short answers to evaluate what students know. It is arguable that closed questions empower a teacher's control in classroom discourse and consequently fail to get students to take more responsibility for their thinking. Compared to closed questions, open-ended ones are more likely to open up classroom discourse by inviting students into the conversation. In particular, researchers have found that when a teacher asks open-ended questions and acknowledges student contributions in a neutral way, they are more likely to "make their meanings clearer", "consider a variety of views", and "monitor the discussion and their own thinking" (van Zee & Minstrell, 1997, p. 258). In short, open-ended questions elicit what students think, encourage them to elaborate on their thinking, and help them construct conceptual knowledge.

Research on school visits to museums has found that museum staff usually ask questions to attract students' attention. However, most of the questions require merely recalling knowledge and very few are asked that involve deep thought or encourage sharing real-life experiences (Tal & Morag, 2007). Regarding this point, in a recent study on student-teacher discourse in classroom and museum settings, DeWitt and Hohenstein (2010) found that closed-ended, often task-related or procedural questions, as well as those seeking brief factual responses, tended to predominate in both settings. In sum, questioning is an important feature of discourse that is linked to power and control, thus understanding the way questions feature in talk may uncover the complex learner-educator relationship in the nature of the discourse. For this study, we focused on the questions posed by the BGEs so as to identify the relationship between them and the students in their discourse during the guided visits.

Storytelling and Analogies in Science Teaching

The communication of scientific ideas to students has been considered as a complex and challenging task which requires "assigning, developing, or expanding meaning; offering a justification; providing a description; or giving a causal account" (Norris, Guilbert, Smith, Hakimelahi, & Phillips, 2005, p. 546). It appears that explaining science is mainly anecdotal, lacking any systematic or thought-out basis (Ogborn, Kress, Martins, & McGillicuddy, 1996). However, research has indicated that storytelling and the use of analogies during instruction is helpful for students to build scientific ideas (Klassen, 2010; Niebert, Marsch, & Treagust, 2012).

Stories are believed to be the primary means by which we make sense of things in our everyday thinking and living (Bruner, 1996). A substantial body of evidence shows that the use of science stories is effective in improving the teaching and learning of science. That is, through a storytelling mode, scientific knowledge, principles, and values can be conveyed to students in an accurate, attractive, imaginative, and memorable way (Kirchhoff, 2008). However, there is no established basis for evaluating stories other than observing their effect on learning when they are used in the classroom. Noting that there are varying viewpoints on the story form of discourse, to frame the definition of "storytelling" used in this study, we adopted the notion of the "literary story" (Klassen, 2009), which highlights the historical and scientific merits as well as the literary merits of the story. Research has suggested that including these stories in science instruction has several benefits, such as: "making the concepts being taught more memorable, reducing teacher-student distance, assisting in illuminating a point, providing 'reasons for needing to know', stimulating the raising of pertinent questions in the minds of students, and producing explanation-seeking curiosity, of both a historical and scientific type, in students' minds" (Klassen, 2009, p. 417).

Analogies have played an important role in scientific discoveries as the means for scientists to explain fundamentally important concepts (Glynn, 2008). An analogy is the comparison of two similar concepts by pointing out shared characteristics, with the goal of showing that if two things are similar in one way, they are similar in other ways as well (Aubusson et al., 2006; Coll, France, & Taylor, 2005). In science education, analogies are viewed as effective teaching tools as they "facilitate understanding the abstract by pointing to similarities in the real world, provide visualization of the abstracts and incite students' interests" (Duit, 1991, p. 414). Although teachers normally acknowledge analogies as being valuable teaching aids, a significant body of research has shown that few are competent in using them during practice. Moreover, teachers were found to use analogies in a mainly descriptive or explanatory way without any critical considerations through a transmission-reception model of teaching (Oliva, Azcárate, & Navarrete, 2007). In order to address this point and enhance students' understanding of science, teachers have been advised

to choose analogues that are familiar to them, with attributes that are precisely identified, and to leave enough time for discussing the comparisons for which the analogy breaks down (Aubusson, Treagust, & Harrison, 2009; Harrison & Treagust, 2006).

Guided School Visits in Botanic Garden and Museum Settings

When compared to the literature about school visits to botanic gardens, much more is known about visits to museum settings. Thus, after first reviewing the limited relevant literature about school groups in botanic gardens, we then examine the research that has been carried out in museums with the expectation of being able to highlight the aspects that are equally valid when applied to botanic gardens. Previous research on school visits to botanic gardens has mainly focused on students' learning experiences by highlighting the affective and cognitive gains (Bowker & Jasper, 2007), the diverse ways of interacting with plants for botanical learning (Sanders, 2007), and the learning process by analyzing student-student interactions (Tunnicliffe, 2001). Moreover, Sanders (2007), when conducting a case study in the London Chelsea Physic Garden, reported that the predominant teaching approach used with visiting school groups was a mixture of traditional and inquiry-based teaching. Sanders criticized the pedagogical approach of botanic gardens towards school groups as being based on "attitudes that focus on behavior management and controlled didactic teaching and learning" (p. 1224).

Likewise, research on school groups in the museum setting has shown that some museum educators have failed to enrich students' learning by following a traditional knowledge-transmission model of teaching. For instance, Cox-Peterson, Marsh, Kisiel, and Melber (2003) found that the museum educators in a US science museum used a lot of scientific jargon without providing students with analogies, information, or explanations to relate the content knowledge to their lives outside the museum. It was also noted that the vast majority of the questions that these museum educators asked were closed and, once asked, lacked follow up, elaboration, or probing. Similar results were found in Tal and Morag's (2007) research on guided school visits in Israeli science museums. It was reported that the didactic way of teaching was commonly observed and when lecturing, the museum educators "stayed at the center, and rarely initiated discussion or listened to the students' questions and stories" (p. 763).

There is a growing trend to examine learning dialogues in research in both formal and informal education contexts; however, much of the research has focused its analysis on the particular linguistic forms or genre of discourse. Although there is an emerging body of research that focuses on the functions of family talk in museum settings (Palmquist & Crowley, 2007; Zimmerman, Reeve, & Bell, 2010), little is known about the functions of informal educators' talk during guided school visits. In order to address this gap, it is important for this study to examine the effectiveness of instructional discourse, which is determined by "the quality of teacher-student interactions and the extent to which students are assigned challenging and serious epistemic roles requiring them to think, interpret, and generate new understandings" (Nystrand, 1997, p. 7).

Methods

In this research, we examined two aspects of BGE's talk during the guided school visits: the functions of their discourse and how this discourse mediated students' learning of science. To address these matters, we followed a qualitative approach which enabled us to inquire into the phenomena taking place in the natural setting (Bodgan & Biklen, 2007; Creswell, 2008).

Participants

Three BGEs from three botanic gardens in England were recruited according to their availability and interest. Table 1 illustrates these participants' science background, teaching qualifications, and teaching experience in botanic gardens. It is notable that all three had a profound science background, particularly Julia, who was initially trained as a plant scientist. Both Simon and Julia were qualified teachers whereas Mark had never received any formal teacher training. During our conversations prior to data collection, Mark stated that he learned how to teach students by observing another BGE's practices for about two years. Compared to the other participants, Simon was an experienced teacher who had been working in an elementary school for 15 years who had been promoted to the position of head of the science department (departmental chair). Julia was a less experienced elementary school teacher, but she had taught secondary (high school) science to special needs students for three years.

[Insert Table 1 about here]

Data Collection

From a set of schools scheduled to visit, two school groups taught by each participating BGE were selected for this research² based on two criteria: that they were accessible to the first author to video record their guided visit and that they were bringing students of the targeted upper elementary grade level (aged 7-11). According to the data provided by the participating BGEs, approximately 70% of their guided visits were delivered for this learner level. Hence, as the aim was to document the common practice of the BGEs as well as any divergence, it was logical to focus on this largest cohort so as to achieve this goal. Table 2 provides information about the school groups and their guided visits.

[Insert Table 2 about here]

As this study set out to explore how the BGEs guided and supported students' learning during the guided visits, we did not analyze the interactions between the BGEs and the accompanying teachers. For most of the time, the teachers were in charge of disciplinary issues and managed the students' behaviors. During the guided visits, the BGEs engaged students with different activities, such as listening to their explanatory talk about plants, collaging plant parts for art-work, pond dipping, observational drawing, and so forth (see Table 2). These activities had either been developed by the BGEs or by their education department.

Four out of six school groups were regular visitors to the participating botanic gardens and we assumed that these students were familiar with the environment and to learning outdoors. Moreover, we unintentionally recruited Group C, of which the majority of students spoke English as an additional language. The inclusion of students who were not native English speakers as well as those who had visited botanic gardens regularly and those who were visiting for the first time reflects the diversity of students that the BGEs encountered during their daily practices. Although the duration and the topics of the guided visits varied, the students participated in similar activities which involved: hands-on exploration of plants, observational drawings, listening to the BGE's talk, and responding to their questions. However, a salient difference was that in Simon's groups a worksheet was used which included a number of open-ended questions that guided students to identify plants living in different environments. In addition, some closed questions were asked such as the temperature in different glasshouses or the reading of rain gauges.

The data source for this study included video recordings of the three BGEs' teaching practices with six visiting school groups for a total of approximately 10.5 hours of footage and the first author was present in the field following each BGE's practice. The camera was stationed at the periphery of the visiting group so as to remain as unobtrusive as possible. The BGEs wore a radio microphone that captured all of their utterances and those of the students with whom they interacted. These means of data collection provided records of whole class discussions and all BGE-student interactions. However, due to personnel constraints, the interactions among students during small group work that were without BGE interventions were not documented.

Data Analysis

All video data were transcribed and each transcription was broken into utterances (an utterance represented a unique idea or contribution to the dialogue). An individual's talk could consist of a single utterance or multiple ones depending on how many ideas were included in one segment of talk. In order to identify the patterns of the BGE-student interactions, we first calculated the percentages of their talk based on the number of utterances. However, the result of such analysis showed that the BGEs' talk predominated the discourse across all cases. Consequently, we further explored this issue by investigating how the power shifted between the BGEs and students during their collaborative talks, which were categorized (after Scott et al., 2006, p. 177) into four classes of communication according to their interactivity and dialogism:

- Interactive/Dialogic: BGE and students exchange thoughts, posing authentic questions and offering, listening to, and working on different points of view.
- Non-interactive/Dialogic: BGE reviews various points of view highlighting similarities and differences.
- Interactive/Authoritative: BGE leads students through a question and answer sequence with the aim of reaching one specific point of view.
- Non-interactive/Authoritative: BGE presents one specific point of view.

In order to identify the functional characteristics of the BGEs' talk, a coding schema for their follow-up moves was developed based on the literature on teacher talk (e.g. Brodie, 2009; Edwards & Mercer, 1987; O'Connor & Michaels, 1996; Ogborn et al., 1996) as well as the coding of our transcribed discourse data (Appendix 1 explains the coding of those moves). 'Confirm' moves relate to when the BGE is not clear about what a student has said and consequently, checks what she/he has heard, while 'evaluate' moves refer to the BGE's judgment on a student's response. In addition, 'insert' moves characterize the instances when the BGE provides students with extra information or explanations directly, and 'evaluate' moves depict the BGE's assessment regarding students' contributions.

According to our analysis, 'confirm', 'insert', and 'evaluate' moves illustrate the authoritative aspect of the BGE talk and, as such, hold little potential for promoting dialogic interactions with students. In contrast, the moves, such as 'maintain', 'elicit', 're-voice', 'press', and 'repeat', shift the power of control to students and further encourage their contributions to the discussion. 'Maintain' moves involve the circumstances that the BGE withholds answers to avoid direct teaching. When eliciting information from a student, the BGE may offer clues to further prompt ideas from that student, whilst 'press' moves occur when he/she expects students to clarify, exemplify, or justify their explanations. By repeating what the students say, the BGE can draw the whole group's attention to an answer or emphasize the educational significance of the particular remark, whereas by re-voicing a student's contribution he/she may add or delete material, use

different words or phrases, in order to clarify, highlight, or reframe aspects of the student's utterance in relation to the current or desired academic content of knowledge. Thus, both 'repeat' and 're-voice' moves can enable the BGE to "place one student in a relation to other students as holders of positions" (O'Connor & Michaels, 1996, p. 77), that is, these moves provide the student with a stance with respect to the topic under discussion, whilst continuing to engage the rest of the class in a relationship consisting of a potentially extended discussion.

As our research focused on school groups in botanic gardens, we anticipated that students volunteering talk (VOL), such as volunteering or sharing information, suggesting actions, or initiating a new topic of conversation, would emerge as an important element of any dialogue (DeWitt & Hohenstein, 2010). As a result, we looked into the content of such discourse by following an open coding approach (Charmaz, 2006) and the student VOL mainly turned out to relate to two aspects: the procedure for completing a certain task (e.g., "Where can I find the thermometer?") and content of a certain subject (e.g. "I saw double coconuts when I was on holiday in the Seychelles."). In addition, we adapted DeWitt and Hohenstein's (2010) coding schema used with teachers to analyze the questions asked by the BGEs (see Appendix 2). Within this schema, BGE questions were grouped into open-ended and closed-ended, with the former referring to those that can encourage content-related description, reasoning and explanation as well as supporting and scaffolding students' conceptual learning. By contrast, closed-ended questions are factual or procedural in nature and request short answers. The two authors coded together one of Mark's guided visits to develop and refine the coding schemas. The notes from the video-clips were also used to provide these raters with a clearer context and subsequently a research student was trained who coded the rest of the transcripts independently along with the first author. The percentage of agreement was 78% for the BGE-student communicative patterns, 72% for the BGE pedagogical moves, 81% for the BGE questions, and 96% for the student VOL. All disagreements were resolved through subsequent discussion.

Findings

In this section we provide the results from our analysis of the discourse which is aimed at addressing two research questions:

(1) What are the functional characteristics and patterns of BGEs' discourse during guided visits?

(2) How is science content communicated to visiting students by the BGEs?

First, we present the percentages and patterns of the BGE and student discourses. Then we discuss these percentages and provide an example regarding how the BGEs follow up students' contributions to the exchanges. Next, we discuss the percentages for the types of BGE questions in order to offer potential explanations for the differences in the patterns of discourse. After noting that a large proportion of the BGE discourse was authoritative and non-interactive in nature, we finally discuss how this pattern impacts on the communication of science to the students.

BGE and Student Utterances

The first emergent issue that required attention was whether the classroom talk was dominated by the BGE or consisted of an interactive pattern that promoted a more active role for the students. Figure 1 shows the percentage of utterances that were either BGE or student talk during the guided visit. It is apparent that the former predominated in the discourse which left little space for the students to expound their ideas. In fact, about 80% of the utterances in these observed guided visits were contributed by the BGE. Consequently, the discourse in these visits was similar to traditional

classroom in that the BGE played a dominant role and contributed most of the utterances. However, simply investigating the percentage of the BGE and student talk does not offer a complete picture of the discourse pattern that was exhibited during guided school visits in this context in terms of the interactions between them.

 [Insert Figure 1 about here]

Therefore, we also looked at the functions of BGE talk to examine whether the BGE was always the main driver of the discourse or whether they opened up the floor for students' contributions. We note that the BGE discourse was mainly interactive (approximately 56%, on average) and authoritative (approximately 68%, on average) in nature. However, a closer examination of the data, as shown in Table 3, indicates that Simon's communicative approach was different from the others, with his employment of a more interactive but still authoritative approach to engage his students in learning about plants. In comparison, Mark and Julia tended to be more non-interactive whilst also maintaining an authoritative role in the discourse. In addition, with the exception of Group F, a large number of the BGE utterances were just interactive/dialogic. In Group F, the interactive/dialogic figure was only about 16% and the late arrival of the these students at the garden, which resulted in Julia shortening the visit and explaining facts directly rather than prompting students for ideas, is the main reason for this low score.

 [Insert Table 3 about here]

In order to find out whether the learning environments created by the BGEs promoted student autonomy, we examined the discourse driven by students (see Figure 2) and a larger proportion of student volunteering utterances were identified in Mark and Julia's groups (about 30%) than in Simon's.

 [Insert Figure 2 about here]

The following excerpt shows an example of a discourse initiated by a student which comes from Mark's teaching about tropical plants in a glasshouse. When the students were given free time to look around the glasshouse, a student (S8) was excited to see a Coco de Mer tree (*Lodoicea Maldivian*) and shouted "Look, I've seen that before at Kew Gardens" (utterance 1) It seems that the child just wanted to share his previous experience with other students, but Mark picked it up and responded "Oh, really? At Kew Gardens" (utterances 2-3) Rather than simply acknowledging the student's volunteering comment, Mark further questioned "What did you see?" (utterance 4), to seek more information from that student and in the subsequent turn of the discourse, the student described the feature of the tree that he had seen before (utterance 5).

	<i>Transcript</i>	<i>Move</i>	<i>Question</i>
1	S8: Look! [<i>pointing to a Coco de Mer tree</i>] I've seen that before at Kew Gardens!	VOL (content)	
2	Mark: Oh, really?	Cfm	Tag
3	At Kew Gardens.	Rpt	
4	What did you see?	Prs	PD

5	S8: The top of the tree against the glasshouse's roof <i>[stretches his arm over his head].</i>	S response (describe)
6	Mark: That's where the double coconuts grow.	Cfm

The transcript below is another example of student VOL taking place in a situation where some students were learning about plant adaptation with Mark. Student (S3) was curious about a cactus plant covered by white hairs and initiated the discourse by posing a question to Mark (utterance 1). Rather than throwing the student's question back to the whole group, he offered a detailed explanation regarding why the Old Man Cactus (*Cephalocereus senilis*) grows white hair (utterances 4-8). In order to mediate students' understanding, he even related the white hair on the Old Man Cactus to the fact that dark-colored hairs absorb more heat (utterances 7-8). In this vignette, it was the student who initiated the discussion; however, Mark did not take up the student's question to facilitate a dialogic inquiry, but instead acted as an information dispenser by sharing factual knowledge authoritatively and monologically.

	<i>Transcript</i>	<i>Move</i>
1	S3: Why there are white hairs? <i>[pointing to an Old Man Cactus]</i>	VOL (content)
2	Mark: Brilliant.	Evl
3	The one over there in the corner is quite hairy; actually it would feel quite soft to us.	Rev
4	The reason why that plant has got those white hairs is to protect itself from too much light.	Int
5	So it's quite useful to be covered by white hairs.	Int
6	If it's covered in black hairs that plant would not survive one day in the desert.	Int Int
7	Those of us with dark-colored hair are probably getting slightly hotter heads than the people with light-colored hairs. <i>[touches blonde and brunette students' heads]</i>	Int
8	Just because dark colors absorb and light colors reflect, like mirrors.	Int

The students in Mark and Julia's groups asked more questions and made more comments related to content, whereas the students in Simon's groups talked more about procedural issues, such as how to read measurements on a thermometer. It is interesting to note that Simon was the only BGE in this study who used a worksheet to assist his teaching and so it could have been the case that his students felt more obliged to complete the worksheet than to explore things that they were interested in. In contrast, both Mark and Julia provided their students with opportunities to conduct hands-on activities, such as making observational drawings, constructing plant collages, pond dipping, and so forth, which facilitated their conducting open inquiry. This could be the reason why their students produced a larger proportion of VOL related to content.

The BGE Responses to Student Contributions

In terms of communicating science, we were interested in not only the structure of BGE-student interactions, but also whether the former facilitated the exchanging of ideas with their students and encouraged their contributions to the discourse. Consequently, we were interested in

how the BGEs followed-up students' contributions to discourse. Table 4 presents the results from our analysis of such interactions.

 [Insert Table 4 about here]

Simon's approach to responding to student talk was different from Mark and Julia's. In his groups, between 42% and 47% of his follow-up utterances ('maintain', 'elicit', 're-voice', 'press', and 'repeat') promoted dialogic interactions with students, whereas between 9% and 17% of these types of discourse were observed in the other two groups. The following excerpt includes an example from the classroom transcript for Simon's group which comes from Group C's visit during which Simon recapped students' previous knowledge about the structure of a plant. He asked the students to use different plant parts made of paper to form a picture of a flowering plant. After a student completed the task in front of the class, Simon asked everyone else to evaluate the student's work (utterance 1). With S2's comment (utterance 2), Simon did not make the judgment whether the answer was right or wrong, but instead he further re-voiced S2's contribution (utterance 3) so as to make it clear to the rest of the class. He then offered clues to elicit answers from the students (utterances 4-6). Simon's elicitation provided the students with an opportunity to think rather than passively waiting to receive the answer. Moreover, it is noted that there was a larger proportion of re-voice utterances in Group C's discourse. Again, this might relate to the fact that most of the students in this group have difficulty in expressing their ideas in English. For example, the response from S2 might not have been clear to the other students until Simon re-voiced it.

	<i>Transcript</i>	<i>Move</i>	<i>Question</i>
1	Simon: Do you agree with him?	BGE initiate	IP
2	S2: You forgot the middle thing [<i>pointing at the picture</i>].	S response	
3	Simon: This young lady thinks he forgot to put something in the middle of the flower.	Rev	
4	This middle thing on this picture is yellow.	Ect	
5	This middle thing would have a special powder.	Ect	
6	Do you know the name of this special powder?	Ect	RA
7	S5: Pollen.	S response	
8	Simon: It's pollen.	Rpt	
9	Well done.	Evl	

As opposed to Simon, who followed-up the student talk more dialogically, Mark and Julia usually made explanations or offered extra information concerning students' commentary or inquisitive talk. Approximately 70% of their follow-up utterances were direct teaching and left little space for prompting students' ideas through dialoguing. Another interesting point is that Simon and Julia employed a larger proportion of evaluative utterances (approximately 13%) than Mark.

Types of BGE Questions

The BGEs questions were analyzed to provide additional insight into the verbal interactions between them and their students. Table 5 displays the number of BGE questions and the proportions of each type.

[Insert Table 5 about here]

Simon asked more questions than Mark and Julia, however, most of his questions were closed-ended (between 70% and 73%). By contrast, the latter two tended to ask more open-ended questions (between 45% and 49%) with the exception of Group F, to which Julia asked a mere 13 questions and only one question was coded as open-ended. During the post-visit discussion with her, she explained that the late arrival of Group F (due to the traffic) had interrupted her schedule. In addition, the schoolteacher still requested her to cover all the pre-determined topics even though the visiting time was shorter than planned. Consequently, as Julia pointed out, she asked fewer questions to save time. However, it is interesting to note that there was still a large proportion of student VOL generated by the students in this group (see Figure 2). Perhaps this high level of VOL was because group F students were older than the others (particularly groups B, C, D, and E) and hence were more likely to take the initiative. Moreover, both Mark and Julia asked a larger proportion of prompt description questions. For example, as presented in the above excerpt, Mark responded to a student volunteering comment about a Coco de Mer tree he had seen before and asked "What did you see there?" to prompt the student to describe more about what he had observed at Kew Gardens. Another salient finding is that a larger proportion of other forms of open-ended questions were observed in Mark and Julia's lessons (except group F). That is, open-ended questions such as "What do you think?" or "How much do you agree?" opened up the floor for students to contribute to the discussion and this approach appeared to stimulate the students' interest as well as engaging them in connecting their ideas with previous experiences.

Despite the pervasive use of closed questions, particularly in Simon's groups, there was an even distribution of such questions. Perhaps, the only difference is that Simon asked a larger proportion of check questions and, according to our analysis, a number of these questions focused on students' completion of the worksheet. In addition, both Mark and Simon involved their students in the lesson discourse as a larger proportion of 'invite participation' questions were identified in their lessons than in the case of Julia.

BGEs' Non-Interactive/Authoritative Types of Utterances

As shown in Table 3, a large proportion of the BGE discourse was non-interactive/authoritative in nature. Thus we investigated this part of the discourse to identify whether the BGEs, especially Mark and Julia, taught by telling. Our analysis shows that the lecturing types of explanations that involved "storytelling" and "the use of analogies" were meaningful pedagogical moves, which have great potential in supporting science communication.

Storytelling. We found that both Mark and Julia usually employed storytelling to explain plants monologically to the students. For example, when the former was explaining the use of medicinal plants, he shared the following literary story:

Mark: If you had surgery on your eyes, the surgeons will look at the back of your eye. They use this plant [points to the Deadly Nightshade in front of the students] to make your eyes really wide open so they can see the back much more clearly. Centuries ago, Italian women used to put the berry juice of this plant into their eyes to make their eyes open wider and make them look even more beautiful. That is why this plant is called Belladonna, which in Italian means beautiful woman. But the thing is they didn't realize they were

poisoning themselves very slowly. Because if you have to take eye drops, if your eyes take eye drops once and then you'll realize that you can taste them about a minute later, because our eyes, our ears and our mouth are all connected to the back to our throat. So they were slowly poisoning themselves for the price of beauty. (excerpted from Group A)

The above story about Italian women who used Deadly Nightshade berries as cosmetics and eventually poisoned themselves conveys the fact that the use of this medicinal plant is a double-edged sword. Mark not only explained the toxicity aspect of this medicinal plant, but also explained how it was named in a historical and anecdotal way. Although Mark narrated the story monologically without inviting any students to contribute to the co-construction of the explanation, the video data showed that most of them appeared to be engaged as they were keeping quiet and listening.

Another interesting example of storytelling is when Julia was teaching the structure of a flower and its reproduction process as follows:

Julia: The stamen is the male part of the flower. So flowers also have male and female parts. When scientists earlier on, in sort of the 18th century, people like Carl Linnaeus were discovering about how plants have male and female parts, people were slightly shocked as they felt the flower is a sort of suitable study for young ladies because there's nothing outrageous in them, sex doesn't come into the reproduction of flowers. But sex does come into the reproduction of flowers, because we have to have male and female parts that are kind of very important in terms of making variations in flowers. (group E visit)

Julia interpreted the sexual reproduction of plants by reviewing the history of botany and the anecdote narrated above appeared to act as an *aide-mémoire* for the students in relation to the functions of different parts of a flower. Again, the students seemed to be passive recipients of factual information. Although Mark and Julia communicated the historical events regarding plants or botanical science in a narrative manner through storytelling, their authoritative and non-interactive approach failed to promote the raising of pertinent questions in the minds of the students. If the BGEs had posed some open-ended questions at certain points of storytelling, the students could have been more intellectually engaged with exchanging ideas in turns or asking questions to demonstrate their explanation-seeking curiosity.

The Use of Analogies. Our analysis shows that Mark was the only BGE who used analogies to support his explanation about plants to the students and a number of such examples were identified in his teaching. For instance, when he was introducing how pitcher plants work to capture insects, he explained that:

Mark: This [points at the pitcher tube] is basically a leaf which is like a deep dark *well* full of some liquid. This [points at the operculum] is the little *umbrella* which keeps the rain out. And at the back [points at the peristome] there's some very sweet stuff. It's quite shiny. It's nectar, a bit like *honey*. (Group B visit)

The analogues “deep dark well”, “umbrella” and “honey” were used to explain the structure of the pitcher plant. That is, for a small insect, such as a fly or ladybird, the pitcher tube looks like a well, which is deep, dark and full of water at the bottom. Here, the pitcher tube is analogized as a water well, which is deep, dark and full of water at the bottom, while the lid or operculum of the pitcher plant is compared to an umbrella, which helps the plant to prevent excess accumulation of rainwater. Furthermore, the nectar was compared to honey as the latter is also sticky and sweet.

Another example of using analogies was also identified in the segments of learning about carnivorous plants. While Mark showed the students a pot of Venus flytraps, he compared the leaves with two pages of a book to explain how the plant captures insects:

Mark: This one (Venus flytrap) is a type like *two pages of a book*. When a fly lands on the surface, it will snap shut and trap the fly inside and it can't get out.
(Group A visit)

The process of carnivorous plants capturing insects was unobservable for those students who observed the Venus flytraps for only a few minutes during the visit, so the analogue of “two pages of a book” provided a vivid explanation of this process that they did not see.

Mark's strategy of using analogies to communicate scientific ideas was authoritative and non-interactive in pattern which did not open up the problem for the students and thus allow him to explore and probe students' views. We did observe that some students were gesturing how Venus flytraps capture insects when he was providing his explanation, which suggest that there was a missed opportunity for increased student engagement and further learning. That is, if there had been a transition in his discourse from authoritative to dialogic interactions, the students would have been more engaged “in the dialogic process of exploring and working on ideas, with a high level of interanimation, within the context of the scientific point of view” (Scott et al., 2006, p. 622).

Discussion

In this paper, we set out to investigate the pedagogical moves of BGEs from a discourse perspective. The findings of this study suggest that, although their discourse predominated during the guided visits, the diverse communicative approaches adopted and the variety of questions asked revealed the complexity of their pedagogical practices. Firstly, the analysis based on the four classes of communicative approach has revealed that the BGE discourse was interactive and authoritative in nature. Despite the fact that interactive/dialogic discourse was occasionally observed, it was overwhelmed by either an interactive/authoritative or non-interactive/authoritative pattern. Mortimer and Scott (2003) point out that in dialogic discourse “more than one point of the view is represented, and ideas are explored and developed, rather than it being produced by a group of people or by a solitary individual” (p. 34). In this regard, the students who participated in the BGEs' guided visits were not given adequate opportunities to represent and explain their different points of view. Instead, their participation in lesson discourse was restricted and controlled by the BGEs. The frequent use of ‘evaluate’ and ‘insert’ moves when the BGEs responded to the contributions made by their students was the supporting evidence for this view. These findings are in line with what previous research on the features of classroom talk has found in that teachers generally maintain authority and control the direction of talk by making evaluative comments (Cazden, 2001) or offering direct explanations as they cannot avoid “telling” (Lobato, Clarke, &

Ellis, 2005). Moreover, it would appear that these pedagogical moves act to remind students who is ultimately in control of the lesson discourse.

Despite the fact that the BGEs manipulated the discourse of the observed guided visits, it was noted that they did sometimes mediate students' making sense of the science content through dialogic interactions. For example, they were found using 'maintain', 'elicit', 'press', 're-voice', and 'repeat' moves when responding to their students' talk. There is abundant evidence that such follow-up moves have the potential for encouraging student participation by sharing their views, and thus promoting dialogic discourse (Edwards & Mercer, 1987; Nystrand, 1997). Furthermore, when the BGEs used open-ended questions that invited responses the lesson discourse opened up beyond the traditional lecture format of teaching by telling. These findings contrast with some previous research investigating school trips to museums during which informal educators asked a large number of questions without follow-up, elaboration or probing (Cox-Petersen et al., 2003; Tal & Morag, 2007).

Our analysis of the BGEs' lecture format of discourse found that scientific ideas were often addressed through storytelling and the use of analogies. For instance, Mark's story of the Deadly Nightshade berry juice as a cosmetic for Italian women would have assisted students in learning about how the use of medicinal plants could be dangerous. Similarly, Julia's story of Carl Linnaeus might have reinforced the students' memory about the reproduction of flowers and enriched their knowledge about the history and development of botany. Matthews (1989) has advocated a historical and philosophical approach to the teaching of school science which, it is claimed, would contribute to a better and more effective conveyance of the nature of the subject. The historical components embedded within Mark and Julia's storytelling would have allowed the students to imagine another time and place "to create their own meaning and find the place, the intersection between the familiar and the unknown" (Bedford, 2001, p. 33). In general, our findings support the argument that storytelling is an important means for science communication to convey information in an accurate, attractive, imaginative and memorable way (Klassen, 2009; Negrete & Lartigue, 2004).

In addition to storytelling, the use of analogies was observed during Mark's lecturing format of discourse through which he made the explanation of carnivorous plants interesting and the unobservable biological process visible. The teaching of science in informal settings has been criticized for its lack of connecting students' personal experience with the exhibits (Griffin & Symington, 1997), for simply introducing scientific jargon to students does not make sense to their learning (Cox-Petersen et al., 2003). The observations from the present study would suggest that the use of analogies should be considered as meaningful practice to engage students and help them to generate personal connections with the content. For instance, Mark used "umbrella", "deep dark well", and "honey" to describe the features of a pitcher plant, which may have facilitated the students as his approach related the content to their daily life knowledge and thus they could easily make sense of the new information. Even though storytelling and the use of analogies have great value in communicating scientific ideas, Mark and Julia maintained an authoritative role throughout their talk without any dialogic interactions with the students. We acknowledge that such kind of storytelling and use of analogies are only possible if the BGEs know their subject well. Thus, it is that "the most fluent exponent of scientific ideas does all of the talking whilst the novices have little or no opportunity to speak the scientific language for themselves and to make it their own" (Scott et al., 2006, p. 622). If we expect students to engage in meaningful learning, they need the opportunity to make sense of newly learned knowledge through their own talk. However, the sight of students gesturing when Mark used analogies to explain a biological process would suggest

that authoritative/non-interactive pattern of talk has the potential to shape opportunities to learn. Therefore, we would argue strongly that the BGEs need to balance their authoritative talk with dialogue, as “both dialogic and authoritative discourse have critical and complementary functions in supporting student learning” (DeWitt & Hohenstein, 2010, p. 456).

Furthermore, we noted that some of the lesson discourse was driven by the students volunteering talk, indicating that they can reverse the interactional roles, change the situational power asymmetry, and wield power to control the discursive interaction (DeWitt & Hohenstein, 2010). The analysis of this student VOL suggests that the goal of the activity, task-oriented or knowledge-oriented, might have an impact on what they would like to address when they initiate the interaction with the BGEs. Moreover, apart from the sociocultural differences, such as language barriers, familiarity with informal settings, and confidence in speaking in public, whether students can take the initiative in the lesson discourse would also appear to relate to the communicative approach of the BGEs. For example, the students taught by Simon generated the least amount of VOL among the three BGEs. This finding can probably be attributed to the fact that, unlike the other groups, his students were visiting a botanic garden for the first time. Moreover, the majority of the students in group C were Pakistani and Bengali immigrants who spoke English as a second language. Therefore, the unfamiliarity with the use of the language could have been a barrier for them playing an active role in the discourse (Cuevas, Lee, Hart, & Deaktor, 2005; Wellington & Osborne, 2001), by, for instance, initiating discussion or posing questions.

There is no doubt that teaching science in informal settings, such as botanic gardens, is a challenging task. It requires educators to be familiar with students' school learning experience, sociocultural background, the needs of the individual learner, and so forth (Cox-Petersen et al., 2003; DeWitt & Storksdieck, 2008; Tal & Morag, 2007). In sociocultural learning environments, as Ash and Wells (2006) have suggested, in order to move towards greater individual understanding, students should be encouraged to participate in knowledge building by sharing what they know and by providing arguments through the ongoing challenge of responding to other speakers. However, whether this outcome can be achieved depends on the content being taught and the type of mediation provided by educators (Tal, 2012). Thus, we believe that the BGEs might benefit from making the content less informative and more exploratory when designing learning activities. They need to bear the principles of learning suggested by sociocultural theory in mind and engage students in joint negotiations through dialoguing. In particular, they might strive to create real discussions, in which educator and students are in equal or similar positions, by shifting the power relation in favor of the latter.

Implications and Further Study

Although this is a small-scale qualitative study, we believe its findings point to several considerations for practice. The detailed picture of the guided visit that we have provided herein emphasizes that the learning environment designed by botanic gardens, or even other informal science institutions in a broader sense, should encourage opening dialogues, which engage both BGEs and students in creating and making sense of knowledge through joint activities. The findings of this study suggest that the facilitation of opening dialogues requires the shift of power in discourse from the educator to the learner. Our advice to educators is to pose open-ended questions and employ certain moves (e.g. elicit, maintain, press, etc.) to encourage his or her students to think, interpret, and make new understandings through their contributions to the dialogic discourse. Such discourse can be an essential feature of effective learning in both informal and formal contexts (Ash & Wells, 2006; DeWitt & Hohenstein, 2010; Nystrand, 1997). Another

important implication of this study is the use of the framework for identifying the pedagogical functions of the follow-up moves which was devised by drawing on studies conducted in and out of the classroom settings, we believe that educators in different contexts could use it as a tool to guide their teaching practices as well as researchers employing it to analyze learning discourses.

One limitation of this research is that it mainly focused on the BGE talk without much consideration of student-student interactions. It would be interesting to investigate to what extent students take account of the BGE talk during small group discussions. Moreover, the present study only explored the dynamic of lesson discourse in BGEs' guided school visits based mainly on the observational data. Thus, in future research, simulated-recall interviews could be conducted with BGEs to discover why they use particular moves (adopting different communicative approaches or asking different types of questions) at particular points. Furthermore, this study focused on BGEs' talk during guided school visits without much consideration of their pedagogical choice, especially why Mark used analogies and Julia employed storytelling to support their explanations of science to their visiting students. In this regard, further work could look in-depth at the BGEs' pre- and post-visit interview data to explore their pedagogical views and their interpretation of pedagogical choice. In addition, it would be beneficial to understand how the BGEs develop their pedagogical identities by investigating their life stories and through ethnographic observations.

Notes

¹ According to the three participating BGEs' statistics, approximately 5,800 students in total would take part guided visits each year.

² The research reported in this paper was part of a doctoral study exploring the pedagogical practices of professional botanic garden educators. A larger number of school groups participated in the larger study than are described in this paper. That is, as this paper set out to explore the discourse of the botanic garden educators, we have only presented the results from the school groups which allowed the first author to video-record their guided visits.

³ For this research, the utterance was the smallest unit for analysis. All the utterances of the BGEs and students were demarcated into real units of speech communication, because according to Bakhtin (1986), "Speech can exist in reality only in the form of concrete utterances of individual speaking people, speech subjects. Speech is always cast in the form of an utterance belonging to a particular speaking subject and outside this form it cannot exist." (p. 71)

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Appendix 1: Coding Schema for BGE Follow-up Moves

Promoting dialogic discourse

- Elicit (Ect): Whilst following up a contribution, the BGE tries to elicit something new from the student or other students. The BGE elicits additional information or a new but related idea to take the lesson forward. Elicit moves often, but not always, narrow the contributions.
- Maintain (Mnt): The BGE maintains the contribution in the public realm for further consideration. The BGE can repeat the idea, ask others for comment, or merely indicate that the student should continue talking.
- Re-voice (Rev): The BGE reformulates a student's discourse to make it clear for the rest of the class.
- Press (Prs): The BGE pushes or probes the student for more on his/her idea, to clarify, justify or explain something more clearly to the rest of the class. The BGE does this by asking the student to explain more why she/he is correct, or by asking a specific question that relates to the student's idea and pushes for something more.
- Repeat (Rpt): The BGE repeats what a student has said in the form of a statement.

Demoting dialogic discourse

- Insert (Int): The BGE adds something in response to the student's contribution. The BGE can elaborate up on it, correct it, suggest something, make a link etc.
- Evaluate (Evl): The BGE makes an evaluative judgment regarding a student's contribution, for example, 'good', 'well done', 'excellent', 'brilliant', 'wrong', etc.
- Confirm (Cfm): The BGE confirms that s/he has heard the learner correctly. There should be some evidence that the BGE is not sure what s/he has heard from the student, otherwise it could be a press situation.

Appendix 2: Coding Schema for BGE Questions (adapted from DeWitt & Hohenstein, 2010)

Open-ended questions

- Prompt explanation (PE): Questions that encourage elaboration of the thinking process, higher-level thinking (i.e., explaining, synthesizing, critiquing, explicating, predicting) or an expansion of ideas. For example: "Why is a bloodworm red?"
- Prompt description (PD): Questions that encourage open-ended description based on observations of what is being seen or done, regarding a particular topic. For example: "What's the difference between a dragonfly and a damselfly?"
- Other open-ended (OO): Questions that are phrased as yes-no questions but may be judged to leave open the opportunity for more reflection than a typical yes-no question or to invite a more in-depth response or reflection. For example: "Are you sure that's the Dragon Blood Tree?"

Closed-ended questions

- Right-answer (RA): Questions that call for a short factual answer. Includes questions for which there is more than one possible answer (but there is a fairly limited set of right answers). This code is also used for leading questions, when the BGE has a particular answer in mind. For example: “What is the reading on that thermometer?”
- Invite participation (IP): Questions that do not necessarily call for verbal answers but that provide an opening for the student to engage physically with an activity. For example: “Would you like to stick the [picture] stem on the wall?”
- Check (CK): Questions that are generally procedural in nature, focusing on the task at hand, or questions that are keeping students on task or making sure they’re progressing with the task. For example: “Have you done your drawings?”
- Clarification (CL): Questions that ask for clarification or repetition of something that has been said. This category is limited to cases where the questioner is misunderstanding, verifying, or checking on understanding. For example: “Do you mean...?”
- Routine (R): Questions that are more about the routine than about the subject matter or task. For example: “Can you stop chatting please?”
- Tag: Used for tag questions. For example: “It looks nice, doesn’t it?”