Rainforest conversations
– How students talk about plants

Abstract
This study examines the conversations of 41 student teachers during visits to a designed rainforest in a greenhouse in a botanical garden in Sweden. The aim of this study is to explore the multimodal affordances of the rainforest for student teachers’ negotiations, and through this obtain an understanding of the potential this environment has for teaching and learning about plants, biodiversity, ecology and life on Earth.

Data for this exploratory case study was collected through observations as well as audio recordings of interactions between student teachers. Data was analysed using multiple tools, including thematic analyses and social semiotics. The results show that the walk-through in the rainforest and the encounters with plants awaken curiosity, raise questions and bring about hypotheses. This has implications for and informs teaching about plants and the importance of plants for life on Earth.

1 INTRODUCTION
This study examines conversations of teacher students during a visit in a constructed rainforest in a botanical garden rainforest. The study will contribute to knowledge about how multimodal and social
encounters with plants can increase not only knowledge about plants but also teaching about plants and the importance of plants for life on Earth. The analytical approach is based in multimodal social semiotics.

Living in urban environments reduces our close contact with nature, which means that landscaped natural environments such as botanical gardens have an increased impact on our contact with the natural world. Previous research has shown that plant blindness (e.g. Wandersee & Schussler, 2001), i.e. the inability to pay attention to plants in the environment, is a widespread phenomenon. According to this theory, it is human nature to ignore the plant world and to perceive it as a green curtain that forms the background to events in the animal world.

The study presented here is part of a three-year research project, "Beyond Plant Blindness: Seeing the importance of plants for a sustainable world", funded 2015-2017 by the Swedish Research Council (Dnr 2014-2013) in which several studies were carried out.

1.1 Plant blindness

Plants are necessary for most life on earth. Without green plants there would be no oxygen and no food; there would be no biosphere. Wandersee and Schussler (1999; 2001) claim that there is a widespread “plant blindness” which entails the inability to see or notice the plants in one’s environment (Wandersee & Schussler, 1999, p. 84) and the inability to recognize the importance of plants in the biosphere and in human affairs (ibid., p. 84). More recent research indicates, however, that this seems to be a simplified description. People do see and even have relationships with plants, often based on memories connected to life experiences (Nyberg, Brkovic & Sanders, 2021), and people do notice and show an interest in plants, although when the plants are placed in an environment with animals, the animals will dominate what is observed (Nyberg, Hipkiss & Sanders, 2019). Other studies suggest that interest in and knowledge of plants differ depending on which plants are in question, and that useful plants such as medicinal plants, stimulant herbal drugs or spice plants might draw students’ attention more than edible plants or ornamental plants (Pany, 2014; 2019). Research has also shown that plants with characteristics such as a distinctive smell, specific adaptive features, conspicuous colour and pattern, an unusual scale, or particular floristic features, including tiny flowers such as blueberry flowers, draw students’ attention (Sanders, 2004; Nyberg & Sanders, 2014; Nyberg, 2017; Prokop & Fančovičová, 2014).

When it comes to acknowledging the importance of plants for life on earth, researchers from the fields of botany and ecology have suggested that knowledge of plants is essential for plant conservation and promoting biodiversity (e.g. Balding & Williams, 2016). This is also argued by Kaasinen (2019), who in his study of plant knowledge among 754 individuals, consisting of students of different age-groups, found that plant recognition was relatively low across the age-groups studied, although it increased with age. Lately the relation between plant blindness and the Sustainable Development Goals (SDGs) has been discussed, and Amprazis and Papadopoulou (2020) conclude from their analysis that education needs to move beyond conventional botany teaching to overcome the issue of plant blindness. This is also stressed in Thomas, Ougham and Sanders’ (2021), examination of the concept of plant blindness.

1.2 Learning in and with plants

From a science education perspective, Braund and Reiss (2006) argue for out-of-school learning that draws on the actual world as a complement to laboratory-based science teaching to increase both learning and interest in science. Sanders (2007) confirms this, and concludes that there is a need for research on varied contexts (school, home, botanical garden), varieties of plant forms (living, model, virtual) and how these are mediated (e.g. tactile interaction) to develop children’s botanical learning (Sanders, 2007, p. 1212).
In a study by Cameron-Faulkner, Serratrice, Macdonald, Melville and Gattis (2017), the affordances of direct and indirect experience of nature for parent-child talk were investigated. Results from their study showed that more plant-related terms were used by both parents and children when they explored the park than when they were in the visitor centre. However, they cannot conclude from their analyses whether it was the children or the parents who initiated the discussions. Therefore, they state that further studies should include analyses of interaction patterns to address this issue. Furthermore, they emphasise the value of direct experiences and how these stimulate both interaction about nature and bring the plant world to life (Cameron-Faulkner et al., 2017, p. 120). This is in line with findings by Nyberg and Sanders (2014), who examined how affective experiences, such as personal encounters, observations and guided explorations, can stimulate students’ attention to plants and plant science (Nyberg & Sanders, 2014, p. 151). By comparing two studies of students’ direct contact with plants in two different settings – a school classroom and a botanical garden – they found that proximity and time to look at plants seemed to favour an interest in and attentiveness towards plants and plant life (ibid., p. 152). Similarly, a study by Comeau, Hargiss, Norland, Wallace and Burman (2019) has shown, by analysing children’s (age 8-10) drawings of plants, that it is a challenge for them to depict specific plant features such as leaves and needles and to draw them in a correct way. One conclusion of their study is that children need more contact with plants in order not to develop plant blindness. This supports the above-mentioned findings about the need to get time to look at plants.

2. THEORY

The importance of language for meaning-making cannot be overstated. However, many other semiotic resources are part of the meaning-making process. For this research, our starting point lies within the theoretical field of multimodal social semiotics, wherein place and the semiotic landscape of the different semiotic resources that become part of interaction and language practices have a similar status to spoken language for analyses, interpretations and our understanding of our findings.

The setting for this study is a presented world-setting, a rainforest in a greenhouse in a botanical garden, and hence it becomes important to examine the role of a place in relation to what goes on within that place. For this, we make use of theories based in Systemic Functional Linguistics (Halliday, 1978). A starting point is also that the botanical garden in this research becomes an interactive and mediating element that is part of the social (Pennycook, 2010, p. 140). As student teachers walk through the rainforest, their interaction evolves when they move past certain plants or stop at certain plants, constructing their understanding of the rainforest and making meaning of what they experience.

Similarly to the rainforest itself being a semiotic resource that becomes part of the meaning-making process, the plants themselves are important “participants” in the interaction, as they draw visitors’ attention, for example by their size, colour or smell (Sanders, 2004; Nyberg & Sanders, 2014) and whether they attract touch as well. Sensory experiences, Mangione (2016) suggests, are socially constructed, and a botanical garden might be a “blurred” space, as visitors might not know whether they are allowed to touch plants or not, whereas smelling them is less of an issue. Signs and written information near plants also become part of meaning-making, and further emphasise the built-in design of how the rainforest is to be understood by its visitors, and are hence important to take into account in relation to the affordances of a place (Blunden, 2016), as language frames the way content is represented and knowledge is constructed (Blunden, 2016:1). Language and its role in the multimodal affordance of the rainforest are further explored in the spoken interaction between student teachers. Therefore, we see the rainforest as an integrative and invented environment (Pennycook, 2010, p. 141) where the language practice and the space of the rainforest and its plants create the meaning-making affordance of the rainforest experience.
3. AIM AND RESEARCH QUESTIONS

The aim of this study is to explore the multimodal affordances of a presented botanical garden rainforest for student teachers' negotiations when they are “left to roam” in the rainforest. By observing what happens in the encounter between plants and students, we strive for an understanding of the potential this environment might have for teaching and learning about plants, biodiversity, ecology and life on earth. We ask the following research questions:

• Where do students initiate interaction and what characterises these interactions?
• Which semiotic resources become part of the interaction?
• What ideas and understandings of plants appear in the interaction?

4. METHODOLOGY

This explorative case study (Stebbins, 2001) attempts to describe and understand what happens in the meeting between plants and people. The explorative approach is justified by a lack of previous similar research in this context, meaning that we do not know what to expect. It does, however, follow in the footsteps of a tradition of research on museum visitors, making use of a number of data collection methods. Previous research has focused on time spent at different displays as a sign of interest and an opportunity for learning. Hillman, Weilenmann, Jungselsi, and Lindell (2016) made use of participant photographs and a narrative created during a school visit to highlight the learning in process during the visit. Similarly, Blunden (2016) made use of the artefacts in displays and the associated written texts to illuminate the interaction between visitors, the objects and the texts, in order to study the afforded meaning-making in an exhibition, and Mangione (2016) included fieldnotes and observations along with transcripts of interaction. Hitchings and Jones (2004) developed a method for studying human-plant encounters using an observational protocol while their respondents walked among the plants in a botanical garden. They found this method especially appropriate when studying movements and reactions relating to plant touch, smell and taste (Hitching & Jones, p. 15). The “Beyond Plant Blindness project” (Dnr 2014-2013) combined a number of these data collection methods, and for this particular research, observation protocols, signs and texts along with visitor interaction form the material used for analyses.

4.1 Data collection

The greenhouse at Gothenburg Botanical Garden in Sweden consists of 11 different rooms connected to a centrally located tropical rainforest. For this study, the student interaction in the centrally located rainforest was recorded. Data was collected over a period of two days. Two different student teacher groups took part in the study: one for lower primary and one for upper primary.

Student teachers walked through the rainforest in groups of two or three on one occasion (10-30 minutes) in the early stages of a course in biology didactics and as part of the aforementioned research project. As the student teachers experienced the rainforest, their deictic movements (as in, for example, pointing and showing with one’s hands) and stops were observed, noted and described in short in an observation protocol (Figure 1), inspired by the study by Hitchings and Jones (2004) described previously. Before starting the tour in the botanical garden, they were given a short introduction to the rainforest in the greenhouse.

Two researchers took turns in shadowing the student groups. One observer shadowed approximately five to ten metres behind the small groups of two to three students, and made notes in the observation protocol. In each group of students, one student had an MP3 player with a Bluetooth connection hanging round their neck. A third researcher handled the recording equipment.

The observation protocol (Figure 1) is a sketch of the rainforest as seen from above, with a selection of plants labelled in the protocol and space left for the observers to make notes on where student teachers stopped and what they did. Plant names in circles indicate that the plants were placed in
pots; otherwise they were planted in the ground in the greenhouse. The wavy lines indicate water. The spiral shape in the top left is a spiral staircase only accessible for employees. Arrows indicate exits or entrances to the other rooms in the greenhouse.

Figure 1. The observation protocol with example comments.

The comments in the example protocol indicates, for example, that student teachers felt the cotton, read the information signs, touched leaves, pointed and read about papaya and pepper. In total, 41 student teachers participated in the study; 14 recordings were collected along with 14 observation protocols (Table 1).

Table 1. Summary of participants, observation protocols and recordings.

<table>
<thead>
<tr>
<th>Student teacher category</th>
<th>BOTANICAL GARDEN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Groups (n)</td>
</tr>
<tr>
<td>Lower primary</td>
<td>8</td>
</tr>
<tr>
<td>Upper primary</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
</tr>
</tbody>
</table>

As the student teachers walked through the rainforest, their interaction was recorded in order to analyse how they talked about their experiences. The student teachers were given instructions to just walk
through the rainforest, and try to ignore the observers and recording equipment. They were informed that the research focus was not on individual performances, but on what that might draw participants' attention in the rainforest and how they talked about it as a group. The research followed the ethical considerations described by the Swedish Research Council (Swedish Research Council, 2017). The student teachers gave their written consent to participate and were informed about the aims of the study, the use of the data, and their rights to confidentiality and to withdraw from participation.

4.2 Analysis

The recordings were transcribed verbatim, and from the observation protocols, we identified and counted locations where the student teachers stopped for a longer time (approximately more than five seconds). These locations were also used to help pinpoint points in time in the recordings in order to analyse the interaction. The analysis of student teachers' construction of the rainforest as a meaning-making “path” as they walked through, stopped and interacted is based in multimodal social semiotics. Data from the observation protocol along with the transcripts and time stamps from the recordings have all contributed to the results in different combinations. For example, the observation protocols identify which plants attract attention, the time stamps from the transcripts in conjunction with the observations illustrate how student groups moved through the rainforest, and the transcript shows the exchanges whilst walking. The protocol and transcripts also give an indication as to whether different signs became part of interaction. There were two types of signs in the botanical garden rainforest: botanical signs that for example give information about the particular plant's name in Latin and Swedish, if known, where the particular plant was collected and where it grows in the wild; and information signs that provide more information about plants, their origins and uses.

The analysis combines different tools from the Systemic Functional Linguistic (SFL) framework. SFL suggest that language construes three types of meaning simultaneously, hence interaction is about something (ideational), it enacts relationships (interpersonal) and it has a form (textual). Even though the three types of meaning appear concurrently, for analytical purposes, it is possible to separate them (Blunden, 2016). The interaction at the plant stops has been analysed as to its ideational meaning – what do student teachers talk about – and the interpersonal meaning – how do they talk about it, as in speech acts such as questions or statements (e.g. Eggins, 2004). The locations were identified and categorised, and form a descriptive account of plants and other objects that attract attention. This creates an understanding of the textual meaning of how the rainforest is tied together and thus constructed by the group as whole and by each group of student teachers. Throughout, plants and other semiotic resources that are included in the teacher student interaction together construe the textual meanings.

_Categorisations of student teacher interaction_

Student teacher interaction was analysed according to turns (Eggins, 2004), meaning sections of interaction made by a student before another student responded or began a new topic. These turns were grouped into three main categories relating to their ideational meaning (e.g. Eggins, 2004). Some of these categories had also been used in a previous study in the same research project, thus allowing for compatibility between studies within the project (Nyberg, Hipkiss & Sanders, 2019). For the purpose of this study, three main categories that best connected to the research questions were used: specific plants, anthropogenic connections and ecology, and a fourth that covered “other”. Each of the three main categories was divided into a number of sub-categories (see Figure 2).

The sub-categories emerged as a result of open coding (Cohen, Manion & Morrison, 2011). These sub-categories were thus a result of repeated readings of the turns, and were negotiated between the two coders, taking into account the theoretically grounded aspects of student turns. These, in turn, related to aspects of plant blindness; findings about features of plants that draw students’ attention (Pany, 2014; Pany et al., 2019; Sanders, 2004; Sanders, 2007) and about adaptive features (Prokop & Fančovičová, 2014); discussions regarding plant blindness in relation to sustainability (Thomas,
Ougham & Sanders, 2020; Amprazis & Papadopoulou, 2020); and findings from studies regarding relations between humans and plants (Balding & Williams, 2016; Nyberg & Sanders, 2014; Nyberg et al, 2021). The coding process was similar to the coding process described in Andersson and Wallin (2000), meaning the process entailed hypothesizing categories based in previous research and checking them against the turns in the transcribed conversations. This resulted in sub-categories such as smell, colour, scale/size, adaptive features (Sanders, 2004), home use (e.g. Pany, 2014) and categories related to research on plants and sustainability (e.g. Amprazis & Papadopoulou, 2020), such as the sub-categories production and environment. This process also established a number of sub-categories unique for this study. The three main categories and corresponding subcategories have furthermore been colour coded (green, pink and blue) and these colours will be used throughout the paper for clarity.

Figure 2. Colour coded categories and subcategories.

Below, two examples of coding is presented to illustrate how interaction turns were categorised during the analytical process:

ST (student teacher): Look at that funny shape. Pear. This turn is coded as Specific plant > plant appearance > shape, as the student teacher comments on the shape and comments on its likeness to a pear (the student teacher was talking about a gourd, Lagenaria Siceraria).

ST: I didn’t know that … rubber came from trees. This turn is coded as Anthropogenic connections> function for humans > product, as the student teacher talks about where the product rubber comes from.

5. RESULTS
The results are presented in three sections. To start, we present the distribution of interaction in relation to the categories and sub-categories. Then, we present examples of how the meaning-making of the rainforest evolved when student teachers walked through the rainforest, and lastly, we present examples of how the interaction evolved exemplifying both what was construed (ideational meanings) and how it was construed (interpersonal meanings) in student teacher interaction.

5.1 Distribution of interaction in categories
The coding of interaction resulted in 815 turns, and the distribution of interaction in relation to the main categories showed that a majority of interaction was within the category of specific plants (Figure 3). As much as 59% (483 turns of 815 turns) of the interaction concerned either identifying specific plants or discussing their appearance. Anthropogenic connections occurred in 22% (179 of 815 turns) of the turns and 15% (121 of 815 turns) of interaction related to plant ecology. Interaction relating to, for example, animals or the space itself amounted to 4% (32 of 815 turns).
Looking in more detail at the sub-categories of plant identification and plant appearance (green), we find that most interaction is concerned with identifying plants (57%; 274 turns of 483) but that their appearance (43%; 209 turns of 483) is clearly something that also attracts attention. A deeper look into particularities relating to both these sub-categories reveals that the student teachers more often discuss “What is it?” about a plant, than they discuss “Is this..?”, indicating they are more often wondering than they are confirming. Plant shape and adaptations are most often the focus for interaction when it comes to plant appearances, whereas smell and colour have fewer codings. This is likely a result of the rainforest having few flowering plants at the time, and hence having mainly different shades of green with no particular scented air from flowers.

The coded items in the two sub-categories of anthropogenic connections (pink): function for humans and in relation to teaching, support the overarching results that the student teachers primarily focus on identifying plants, and having done this, they discuss the plants and how they are used by humans (77%; 138 turns of 179). Plants in relation to teaching is less prominent (23%; 41 turns of 179). The
rainforest as a classroom is a discussion point in some groups and the student teachers are then concerned with, for example, their lack of knowledge, the lack of good informative signs and also questions about how to actually teach inside the rainforest. However, the plants’ different functions for humans is the main sub-category, and a wide repertoire of issues to do with workers’ rights, industry and its environmental impact, and whether plants do well in a home environment or not, are discussed here.

In the ecology category (blue), the interaction was coded into the four sub-categories biotope, geography, climate and symbiosis/parasitism. Issues relating to plants and their biotope came up most often (32%; 39 turns of 121) and concerned how plants “interact” with their surroundings. The sub-category geography, which is related to questions of biotopes and climate, is mainly about the actual places where plants live (25%; 30 turns of 121). Students most often found information about this on signs. Turns that are coded as climate contain two strands of ideational meaning, either climate in rainforests in general or climate in relation to specific plants (12%; 15 turns of 121). Finally, there is student interaction that concerned plants and their relation to other plants as being a question of either symbiosis or parasitism (10%; 12 turns of 121).

5.2 How the meaning-making of the rainforest evolved
As the student teachers walk through the rainforest, their “construction” of the rainforest evolves differently. The fourteen groups spend, first of all, different amounts of time walking through, from 3 minutes to 25 minutes, and stop at different places and for different amounts of time. The students either walk the rainforest clockwise or anticlockwise. There are different initial impressions because of this, which might affect what plants are noticed and how they are noticed. Clockwise, visitors appear to walk towards an enclosing rainforest with hanging and tall plants. Walking anticlockwise visitors are lead into a more open aspect. There are few tall trees to the right but rather an opening towards the windows, which makes that latter route slightly brighter.

Figure 5 summarises the number of stops and lists the six most popular plant stops during the student teacher walks. Out of 207 stops, cacao comes out on top with 6.67% of the stops, and cotton and rubber trees tied in second place (6.28%). The Japanese climbing fern comes in fourth place (5.79%), and pepper and *Amorphophallus* share the fifth place (5.31%).

<table>
<thead>
<tr>
<th>Number of stops: 32 places</th>
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</thead>
<tbody>
<tr>
<td>Total number of stops for all groups: 207</td>
</tr>
<tr>
<td>Six most popular plant stops:</td>
</tr>
<tr>
<td>1: Cacao (<em>Theobroma cacao</em>) 6.76%</td>
</tr>
<tr>
<td>2: Cotton (<em>Gossypium spp Malvaceae</em>) 6.28%</td>
</tr>
<tr>
<td>Rubber tree (<em>Hevea brasiliensis</em>) 6.28%</td>
</tr>
<tr>
<td>4: Japanese climbing fern (<em>Lygodium japonicum</em>) 5.79%</td>
</tr>
<tr>
<td>5: Pepper (<em>Piper niger</em>) 5.31%</td>
</tr>
<tr>
<td>(<em>Amorphophallus</em>) 5.31%</td>
</tr>
</tbody>
</table>

*Figure 5. Summary of stops and popular plants to stop at in the rainforest.*
Below, two examples of walk-throughs by Group A and Group B are illustrated using the same colour coding for the ideational analytical categories as previously. The colour coding, shows that specific plants attract more attention and interaction than others, making this category most dominant, followed by conversations about ecology-related issues. There are also some examples of interaction relating to anthropogenic connections.

The two groups (A and B) have been chosen as Group A is representative of an average walk-through and Group B is an example of a student teacher group that spent a long time in the rainforest and whose interaction mainly focused on plants in one of the three main categories of coding. Group A consists of three student teachers. Their walk last for 11 minutes and they make six stops during their tour. Group B consists of four student teachers and they spend 24 minutes walking through the rainforest, making eleven stops along the way.

Figure 6 illustrates the distribution of coded interaction in the three main categories for the two groups. Both groups talk about specific plants to the same degree (approx. 30% of the coding). Group B talks about ecological issues to a similar degree (approx. 30%) whereas Group A talks less about plants and their relation to ecology (17%). Group B also talks more than Group A about plants in relation to humans (24% vs 11%). One substantial difference is that Group A’s interaction to a great extent (41%) is concerned with other aspects of the rainforest, e.g. animals and general experiences. The corresponding proportion for Group B is 16%.

Figure 6. Percentages of coded interaction in the main categories for the two student groups, A and B.

Both groups walk in the same anticlockwise direction (Figures 7 and 8), stopping initially at the cacao tree where they firstly are concerned with the identification of the cacao plant and then its geography. Group A (Figure 7) discusses the cacao plant more, bringing in aspects of geography, and of appearance, such as ripeness and colour. Group B (Figure 8) moves along after establishing that it is a cacao tree and where it can be found in the world.

Group A appears to focus most on specific plants which are utility plants that they have met in other circumstances: cacao, bamboo, cotton, rubber tree and pitcher plants. Group B explores more than Group A, and does not only stop at familiar plants, but their attention is also caught by plants’ appearances. Group B stops at different types of plants, both utility plants they recognise from before and plants that draw their attention for other reasons. Group B also make more use of the signs in the rainforest.

The two groups do not stop at the same places in the rainforest, and therefore can be said to make different meaning of the rainforest from this locational perspective. The differences between groups also tell us that the student teachers construe the space of the rainforest differently. They are attracted to different plants and we find that focus for interaction also varies between groups in relation to the three main categories of interaction.
Figure 7. Group A walk-through (green: specific plants, pink: anthropogenic connections, blue: ecology).

Figure 8. Group B walk-through (green: specific plants, pink: anthropogenic connections, blue: ecology).
5.3 How the interaction evolved – the what and how of interaction

The following presentation focuses on how student teacher interaction evolved as they walked through the rainforest. The presentation is divided in three sections, each focusing on one of the main analytical categories of specific plants, ecology and anthropogenic connections, with examples from different student groups (labelled in the extracts, e.g. LPGrp2A=Lower Primary student teachers, Group 2A, UPGrp2=Upper Primary student teachers, Group 2). In our presentation, we also illustrate how they use different semiotic resources for meaning-making, how they make sense of plants and their lives by hypothesising, and how they discuss and make sense of plants and their role in human life by connecting this to both (or either of) production and products.

Specific plants

In addition to the semiotic resources of spoken language and individual plants that become part of the meaning-making process, signs are also important sources of information, either to identify plants or to learn more about the plants. The following examples illustrate typical interaction where student teachers ask a question and, with the help of a sign, they find the answer, either themselves or together with another student teacher.

One group discovers a *Huperzia Erosa*, which they seem to be drawn to because the plant looks “cool” and reminds them of club moss found in Swedish forests. They discuss the likeness and dissimilarities and try to make sense of its leaves as they look different from the club moss that the students are familiar with. In this section of the exchange, they both describe how the end of the leaf “splits” and enhance the experience of this with an onomatopoetic expression of how the leaf spreads: “One root and then just *fizzzsshhh*”. The students also make use of the sign provided, which informs them about what an epiphytic plant is and about the *Huperzia Erosa* in particular. The interaction here is characterised by statements where students reaffirm one another’s reasoning.

<table>
<thead>
<tr>
<th>ST1: I wonder what this is. Cool. It looks like club moss, you know, but it sort of splits.</th>
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</thead>
<tbody>
<tr>
<td>ST2: Yes, I recognise it now.</td>
</tr>
<tr>
<td>ST1: Yes, exactly.</td>
</tr>
<tr>
<td>ST2: Perfect.</td>
</tr>
<tr>
<td>ST1: Yes. Really cool.</td>
</tr>
<tr>
<td>ST2: Exactly, it looks... just like. It’s got the same shape, sort of. One root and then just <em>fizzzsshhh</em> like that.</td>
</tr>
<tr>
<td>ST1: Yeah. Here’s something... well that helped a lot. Hu, Hu. <em>Huperzia Erosa</em>. Yes it says club moss here. Epiphytic club moss, oh that’s cool! Epiphytic is... it’s a plant that grows on another <em>laughter</em>... It plants itself on branches and such and then it puts its roots and grows. Cool. It is sort of like club moss but it’s like this... It’s really nice looking too. It looks like troll’s hair.</td>
</tr>
</tbody>
</table>

Interaction   | *Huperzia Erosa* |
---|---|

Extract 1 (UPGr2). Extract 1- Specific plants – Identification – What is it?
The interaction in the rainforest also provided examples of student teachers hypothesising about plants, for example about how they spread and how they grow or how plants might have adapted to prevent animals from climbing. These exchanges include for example hypothesis of which animals might climb a thorny stem tree. The answers to many of these hypotheses are not found on any signs and both lack of information and botanical signs as being illegible has been mentioned by students as they lack the knowledge to read/interpret them.

**Anthropogenic connections**

Interaction that includes anthropogenic connections relates to plants that students recognise as houseplants or similar to houseplants. There are also examples of conversations that retell student teachers’ own experiences of being in rainforests and, for example, watching people work in the rainforest, and also memories of socio-culturally shared experiences such as TV programmes and films (e.g. *George of the Jungle* and the “Whomping Willow” in *Harry Potter*). The extracts below, however, focus on aspects of human impact on plants, the life of plants, humanity and our planet as a whole. Furthermore, there is interaction whose ideational meanings relate to the cotton plant, its size and the realisation of how long it would take to pick cotton, and the working conditions in the cotton industry, both historically and in modern times. The students make use of the information sign that provides information about the plant as such, its historical use and the current situation in relation to both industrial and manual production and water use, to find answers to their questions.

**ST3:** Okay, are these little ones you pick to make cotton? ... It must take a really long time. Oh no, now I feel really bad about that.

**ST2:** Where are these from then?

**ST3:** Mali... Pakistan... Uzbekistan.

**ST1:** Yeah, you feel bad when you see they are so far apart.

**ST3:** Yeah, I don’t know ... maybe it’s... I don’t know. If you compare with others perhaps it’s better than... but it really uses lots of water, doesn’t it?

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Cotton</th>
</tr>
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All participating student teachers will become eligible to teach science in primary school and some of their interaction concern the rainforest as a “classroom”. They discuss, for example, the difference in perspective due to height differences between school children and teachers and the affordance of the rainforest as a playground, for example for hide and seek.
Student interaction in this category also brings up issues relating to background knowledge, knowing how to read botanical signs, and knowing about the plants, i.e. what to do if asked a question by a pupil they did not know the answer to.

**Ecology**
Student teachers also hypothesise about ecological issues, as in Extract 3. One student teacher interaction focuses on pitcher plants (*Nepenthes*), how they might grow in the rainforest, and how their long stems might assist in climbing, or not. The plant in the botanical garden rainforest grows in a basket that hangs from the ceiling and the student teachers try to come to an understanding of how it would grow in its natural environment.

![Pitcher plant](image)

**Extract 3 (LPGrp5A). Ecology – Symbiosis/Parasitism.**

Other groups bring up for example geography either to find out where plants might grow or to confirm existing knowledge.

### 5.4 Summary
To summarise the findings: student teachers construe the rainforest differently and make different meaning based on where they stop and how they talk about plants.

In relation to our first research question regarding where interaction takes place and what it concerns, the numbers of stops indicate that the students first of all want to know what plants they are looking at. Once they have identified the plants, they sometimes move on and make meaning of them in relation to for example anthropogenic connections or ecology.

Our second research questions focused on semiotic resources in interaction. For the most part, spoken language is the main semiotic resource in all groups. Spoken language is combined with the reading of botanical signs and other information signs when these are available, and some groups also
make use of semiotic resources such as touch and smell when talking about plants. Interaction that is based around plants that are familiar to the student teachers, either as household products, such as foodstuffs, spices or other products, for example rubber, combines other semiotic resources alongside spoken language. These plants have more information signs compared to other plants, including both botanical signs and descriptions of the plants and their uses that become part of meaning-making. Other plants that attract attention are plants recognised from the forest (e.g. club moss). Some of these plants also have signs with information about more than name and origin etc.

Our final research question focused on ideas and understandings of plants in the student teachers’ interaction. We find that the student teachers often ask questions, to whoever might answer within the group, including themselves. Sometimes their interaction leads to an answer; other times it leads to another question or a hypothesis. The student teachers also tell each other about plants, for example by relating to their own knowledge or other experiences, but often also from what they read on the signs. However, a “general impression” from the results is that the rainforest raises more questions than it provides answers to.

6. CONCLUSIONS
This study shows the potential of a constructed rainforest in a botanical garden when it comes to providing multimodal and multisensory experiences. Here it is possible to feel, smell, listen to and see plants in a living, albeit constructed, environment. In line with previous research, sensory experiences enrich understanding and interaction (e.g. Cameron-Faulkner et al., 2017; Nyberg & Sanders, 2014; Prokop & Fančovičová, 2014), making a strong case for out-of-school visits for pupils and university students alike.

The results of our study also provide support for Pennycook’s suggestion that a space, such as in this case the rainforest, is an interactive and mediating element that is part of the social (2010. p. 140). The way that the student teachers walk through the rainforest impacts their interaction with each other, which in turn probably influences and affects their understanding and meaning-making of the rainforest and its plants. Their spoken interaction makes their ideational meaning-making, as in what they bring up in relation to plants, visible. What is said is often combined with other semiotic resources, such as the texture of a leaf or the (lack of) smell of a plant and information signs, highlighting the function of verbal language as framing content and knowledge (Blunden, 2016; Cameron-Faulkner et al., 2017).

The students are drawn to plants for different reasons; there is the “need for knowledge” in relation to wanting to know more, but also awe towards plants (Sanders, 2004; Nyberg & Sanders, 2014; Nyberg, 2017), their function for society (Pany, 2014) or ecosystems (Amprazis & Papadopoulou, 2020; Thomas, Ougham & Sanders, 2021). The students when noticing a plant, want to know “here and now” what they are looking at, but also possible genetic connections between different plants, the biological life of the plants and how the plants are used or affected by humans. Their conversations are characterised by explorative questions which are not necessarily answered, but if they are, the information signs are of use, as well as student teachers hypothesising together or reasoning towards some kind of answer, or reaching agreement that they do not know. In connection to their questions and curiosity, they also bring in issues of the rainforest as an alternative classroom (teaching and learning space), discussing how and what to teach with a group of pupils, acknowledging that educational out-of-school activities such as these do provide a learning context which can offer affordances which are not possible to achieve in a classroom.

To close, our study contributes to the knowledge base regarding the potential of a multimodal environment such as a constructed rainforest in a botanical garden, when it comes to teaching and learning about plants, biodiversity, ecology and life on earth. Through our simultaneous analyses of observational protocols and transcripts of the recordings of the conversations between the student
teachers, we have been able to get an understanding of both where interactions between the students take place and the nature of those interactions. We have also become aware of the significance of verbal texts on the signs adjacent to the plants. Our study has also shown that rich conversations can be the result of a short visit in this specific environment, dealing with a multitude of aspects relating to the plants and life on earth. We can clearly see that there is an aspiration among the student teachers to know more about the plants they come in contact with. A conclusion is therefore that educational out-of-school activities such as these do provide a learning context which can deepen knowledge of and interest in plants. Especially striking are the developed discussions and reflections that took place as a result of getting an insight into the various utility plants in the setting, which support the suggestions put forward by others (e.g. Pany, 2014), that taking utility plants as a starting point in teaching might create an interest in plants and a desire to know more.

However, if these kinds of environments are not easily at hand, there are still possibilities to organise teaching and exciting discovery opportunities, for example by cultivating, observing and taking care of plants in a classroom or in the school-yard, thereby achieving some of the positive aspects of “authentic” learning and close contact with and detailed observations of plants, albeit not exotic ones, as in the present study (Nyberg & Sanders, 2014; Nyberg, 2017).

This research is thus a response to Sanders’ (2007) call for more research on teachers’ and learners’ perceptions of plants. It is also a contribution to biology and environmental didactics and thereby a response to Thomas, Ougham and Sanders (2021), who in their examination of the concept of plant blindness conclude that education is essential and that the training of teachers is critical.

Limitations
Since the data consists of only 14 recordings and observational protocols, the results cannot be generalised. Our methodology and analyses make it possible, however, to get a detailed insight into the nature and amplitude of the student teacher conversations and other interactions that take place between the primary student teachers and between the students and the plants. The fact that the students were “shadowed” in two ways, both by being observed and recorded, albeit at distance, can of course have affected their way of acting and talking, and this might in fact be one reason for the difference in time spent and the extent of conversation between the groups. Our conclusion is, however, that our exploratory case study has given valuable insights, despite the small-scale nature of the study.

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