



# Inquiry-based field trip to a botanical garden

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**Gonçalo Nuno Carreira Pereira**

Escola Profissional de Ciências Geográficas, Lisboa

**Helena Moita de Deus**

Agrupamento de Escolas Amadora Oeste, Amadora

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# Theoretical Background

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Out-of-school learning experiences involve many characteristics of formal learning, complementing it by allowing the construction of knowledge with personal meaning, the realization of genuine choices and challenging tasks, taking control over the process of learning and collaboration with others. (Tal, 2013)

Visits to locations beyond the classroom offer students opportunities to develop new skills, observe actual specimens rather than models or photographs, and stretch their senses. (Dillon, 2013)

# Theoretical Background

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“Botanical Gardens offer learning opportunities for practical and multi-sensory activities with plants.”  
(Martins-Loução & Gaio-Oliveira, 2017, p. 10)

Educational activities in the Botanical Garden are inevitably dynamic and very enriching, offering an immense availability of educational resources and direct contact with real models and authentic examples of natural phenomena. (Tavares, Silva & Bettencourt, 2015a)

# Theoretical Background

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In this context, inquiry-based science education provides students with an inspiring environment with the needed tools and opportunities to discover and use them on their own. (Tavares, Silva & Bettencourt, 2015a)

The essential features of inquiry are:

- learner is engaged in a scientifically oriented question,
- learner gives priority to evidence in responding to the question,
- learner uses evidence to develop an explanation,
- learning connects the explanation to scientific knowledge,
- learner communicates and justifies the explanation. (Bybee, 2006)

# Theoretical Background

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When developing an inquiry-based science education activity, the teacher does not explain everything but is a facilitator who supports the students in finding their own solutions and provides help only when needed or required. The teacher or educator plays a key role as organizer and promoter of a working environment conducive to knowledge building processes and helping critical thinking and reflection of students. (Tavares, Silva & Bettencourt, 2015b)

To take full advantage of an inquiry-based field trip to a botanical garden, a good preparation is needed. The teacher should make an exploratory visit to develop learning situations that explore the new context in order to promote a more meaningful learning (Galvão et al. 2006).

# Theoretical Background

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Field trips are an extension of the formal science classes, functioning as an integrating element of contents and learning. In some cases, they are a motivational element to later allow the consolidation of learning in the classroom. In other cases, they constitute a form of consolidation of previous learning.

For the experiences to be effective they must be planned, carefully implemented and should continue to be worked on when back into the classroom (Dillon et al., 2006). Therefore, field trips should always be structured around pre-visit orientation lessons and follow-up lessons (Orion, 2001).

# Theoretical Background

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It is also important to emphasize that the most effective way to teach students about the Nature of Science and about Scientific Inquiry is through an explicit and reflective teaching approach (Lederman e Lederman, 2013).

The formative assessment can help teachers and pupils to feel more confident in the steps of inquiry-based science education and improve their achievements. Therefore, formative assessment is an ideal assessing approach. (Rokos, Zavodska, Petr & Papacek, 2016)

# Lisbon Botanical Garden

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Lisbon Botanical Garden belongs to the National Museum of Natural History and Science of Lisbon University. It is a scientific garden that was classified as a national heritage monument in 2010.

It was designed in the 19th century and began to be planted in 1873, thanks to the dedication of teachers Andrade Corvo and Count of Ficalho, and was open to the public in 1878.

With an area of 4 hectares of garden, it is possible to travel the world in space and time: to know a huge diversity of exotic plants and other plants that dominated the landscapes in the past.

# Learning Strategy

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## Purpose

To develop an activity, according to the Inquiry-Based Science Education (IBSE) methodology, focused on a field trip to the Lisbon Botanical Garden (LBG), that promotes the learning of Natural Sciences.

## Goals

- To develop a didactic strategy through inquiry in a science museum.
- To assess formatively the impact of the strategy on student learning.
- To reflect on the implementation of inquiry activities in school.

# Learning Strategy

## Curricular Framework

**Subject:**

Natural Sciences

**Curricular contents:**

Earth's sustainability

Ecosystems and Sustainable Resource Management

## Investigative Skills

Identify problems

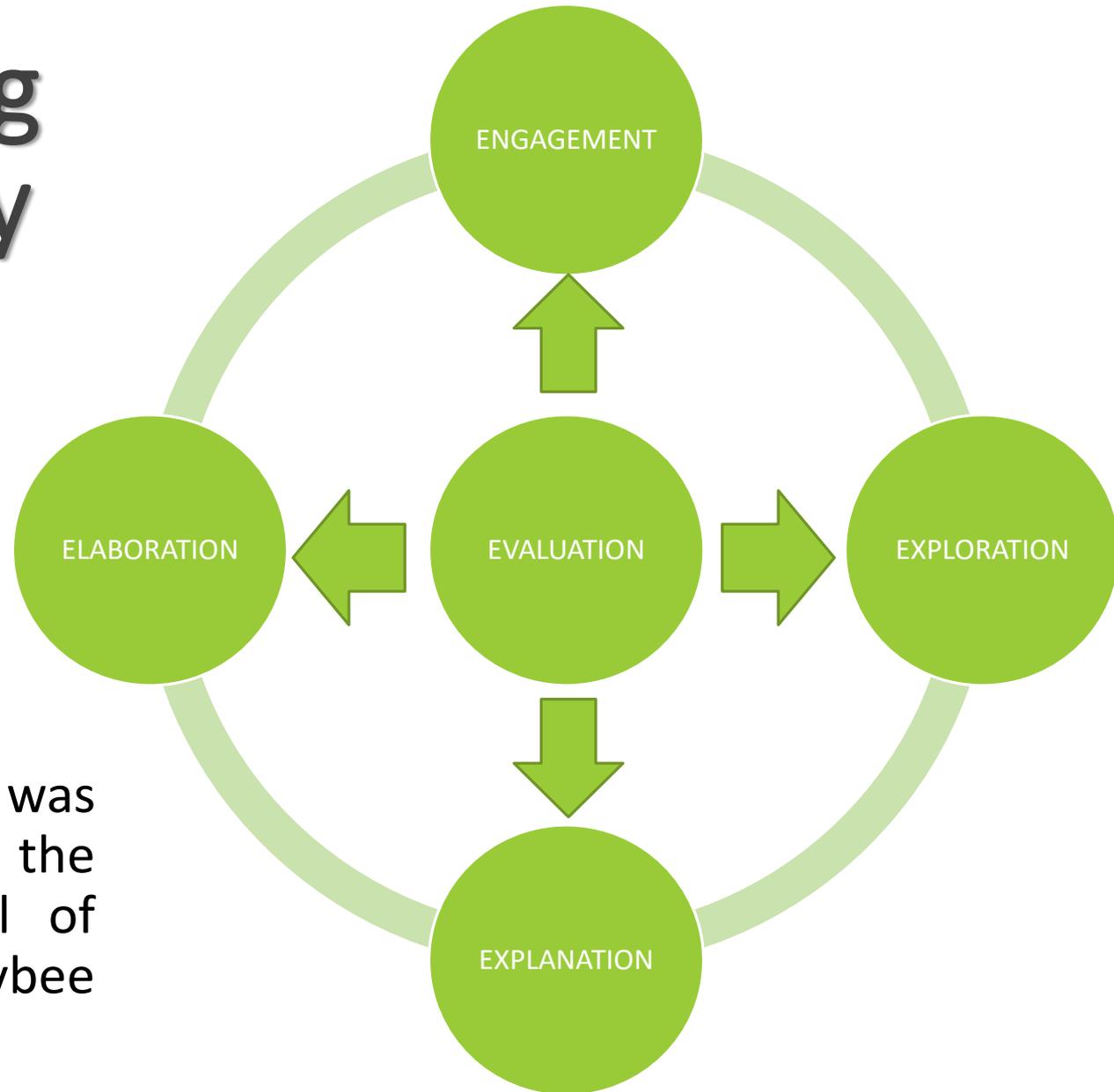
Plan investigations

Analyze and interpret data

## Participants

29 students from an 8th grade class at a school in the region of Lisbon

# Learning Strategy



The activity was planned based on the theoretical model of the 5 E's of Bybee (2006).

# Learning Strategy

*Table - Learning Strategy*

<b>Phases of the activity</b>	<b>Pre-visit orientation lessons</b>	<b>Field trip to the Botanical Garden</b>	<b>Follow-up lessons</b>
<b>Tasks performed by students</b>	<ul style="list-style-type: none"> <li>– Identification of the problem</li> <li>– Planning data collection</li> </ul>	<ul style="list-style-type: none"> <li>– Data collection</li> </ul>	<ul style="list-style-type: none"> <li>– Analysis and discussion of the results</li> <li>– Research the questions that emerge during the investigation</li> <li>– Communication of the investigative work developed to the class</li> <li>– Integration with other investigative activities</li> </ul>
<b>Assessment tools</b>	<ul style="list-style-type: none"> <li>– Pre-conceptual maps</li> <li>– Assessment tools for problem definition and data collection planning</li> </ul>	<ul style="list-style-type: none"> <li>– Field notes</li> </ul>	<ul style="list-style-type: none"> <li>– Post-conceptual maps</li> <li>– Assessment tools for the presentation and analysis of data</li> <li>– Final reflection (Content analysis)</li> </ul>

# Learning Strategy

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The pre-visit orientation classes included two phases of engagement.

The first phase of engagement for the class targeted the agglutinating theme of the activity: "The Botanical Garden as a privileged space for learning outside the classroom".

At this stage, the class constructed a concept map based on the questions: "What is a Botanical Garden?" And "What is the use of a Botanical Garden?" (ENGAGEMENT).

This class was also used to introduce the use of the IHMC CmapTools program to build concept maps, in articulation with ICT subject.

The construction of this conceptual map permitted the identification of the initial ideas of the class (EVALUATION), and recognition of some alternative conceptions.

# Learning Strategy

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The second phase of engagement included the introduction of a theme for each group through Concept Cartoons (CC) (Naylor and Keogh, 2000), which allowed them to focus on the theme and to initiate the discussion (ENGAGEMENT).

To each of the six groups of students were drawn the following topics: biotic relations; adaptations to different humidity conditions; adaptations of carnivorous plants; plants as natural resources; conservation of plant biodiversity and the life cycle of butterflies.

# Learning Strategy

Plants of very humid ecosystems can live in very dry environments!



The plants of dry environments have adaptations to lose little water!

The plants of environments with different moisture content are very different!



Plants of aquatic ecosystems need to be able to search for air!



# Learning Strategy

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From the analysis of the CC each group identified their problem and started the development of the first version of the conceptual map (EXPLORATION).

The pre-conceptual maps permitted the identification of students' knowledge about the subject.

Through a checklist, the definition of the research problem to be investigated in the field trip to the Botanical Garden was assessed (EVALUATION) .

# Learning Strategy

**Table** - Checklist to assess the definition of the research problem

Item	Descriptors (performance levels)
<b>Suitability of the problem to the content explored in the Concept Cartoon</b>	Problem unframed in the Concept cartoon theme (1)
	Problem framed in the Concept cartoon theme (2)
<b>Closed or open-end definition of the problem</b>	Closed problem (1)
	Open-end problem (2)
<b>Degree of comprehensiveness of the problem</b>	Problem not comprehensive (1)
	Comprehensive problem (2)
<b>Operationalization of the problem</b>	Irresolvable problem, under existing conditions (1)
	Resolvable problem, under existing conditions (2)

# Learning Strategy

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In the next class the students finished the tasks and started planning the data collection (EXPLORATION). The students were given lists of species of living beings to study and the map of the Botanical Garden with the location of their species. Research planning was assessed through a rubric (EVALUATION).

During the fieldtrip to the Botanical Garden, data collection was carried out according to the planning. Students made records of the observations (EXPLORATION). The observations of the work developed in the Botanical Garden was recorded in field notes (EVALUATION).

# Learning Strategy

*Table - Rubric to assess the planning of the research*

Items	Descriptors (performance levels)			
	Emerging	Developing	Consolidating	Extending
<b>Materials required for data collection</b>	The group of students makes a first attempt to identify the materials needed.	The group of students identifies as necessary the writing materials (pencil, pen and paper).	The group of students identifies as necessary: Writing materials; Camera and Camcorder.	The group of students identifies as necessary all the materials referred in the previous level and also: Maps/plans and Measurement/orientation instruments.
<b>Methods of data recording</b>	The group of students shows difficulties in identifying the methods for recording the data.	The group of students refers to written notes as a method for data recording.	The group of students refers to written notes as a method for data recording and also one of the following: Drawing; Photography and Video.	The group of students refers to written notes as a method for data recording and also two of the following: Drawing; Photography and Video.
<b>Selection of data to be collected</b>	The group of students makes a first reflection regarding the data to collect.	The student group identifies some of the data to be collected to solve the problem.	The group of students identifies the data needed to collect to solve the problem.	The group of students identifies the data needed to collect and reflects on the validity of the data to solve the problem.

# Learning Strategy

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In the follow-up lessons, students did the analysis and discussion of the results (EXPLORATION), autonomously, then communicating their conclusions properly substantiated (EXPLANATION).

The questions unanswered with the data collection were solved with bibliographical research (ELABORATION).

At this stage students were supported through the Moodle platform and via e-mail. In this way, feedback was provided about the presentation in order to be able to improve it - formative evaluation (EVALUATION).

In a classroom lesson, the students communicated the investigative work developed to the class (EXPLANATION).

The analysis and treatment of the data exposed in the PowerPoint presentation was done through a rubric (EVALUATION).

# Learning Strategy

*Table - Rubric to assess the analysis and treatment of research data*

Items	Descriptors (performance levels)			
	Emerging	Developing	Consolidating	Extending
<b>Selection of collected data</b>	The group of students revealed difficulties in selecting the data needed to support the resolution of the problem.	The group of students selected some data needed to solve the problem.	The group of students selected the appropriate data to solve the problem.	The group of students selected the appropriate data to resolve the problem and in addition, after a search, selected data to answer questions that arose during the investigation.
<b>Organization and processing of collected data</b>	The group of students made a first attempt to organize and process the collected data.	The group of students organized the data collected and carried out their treatment in a partial way.	The group of students organized the data collected and made their treatment using graphical representations such as tables, graphs, conceptual maps, among others.	The group of students organized the data collected and made their treatment using graphical representations such as tables, charts, conceptual maps, among others, reflecting on the adequacy of the representation for a better reflection about the defined problem.
<b>Descriptive analysis of the data collected</b>	The group of students presents a rudimentary descriptive analysis of the collected data.	The group of students did a partial descriptive analysis of the data.	The group of students made a descriptive analysis appropriate to the collected data.	The group of students made an appropriate descriptive analysis to the collected data, relating them in a way that allows an integrative view of them facilitating their discussion enabling the resolution of the initial problem.
<b>Discussion of the results</b>	The group of students revealed difficulties in discussing the data collected.	The group of students made the discussion of the data collected in a partial and fragmented way.	The group of students made an appropriate discussion of the data collected by their integration to solve the initial problem.	The group of students made an appropriate and integrated discussion of data collected, making a generalization of the conclusions from the investigation of the species, in order to solve the initial problem.

# Learning Strategy

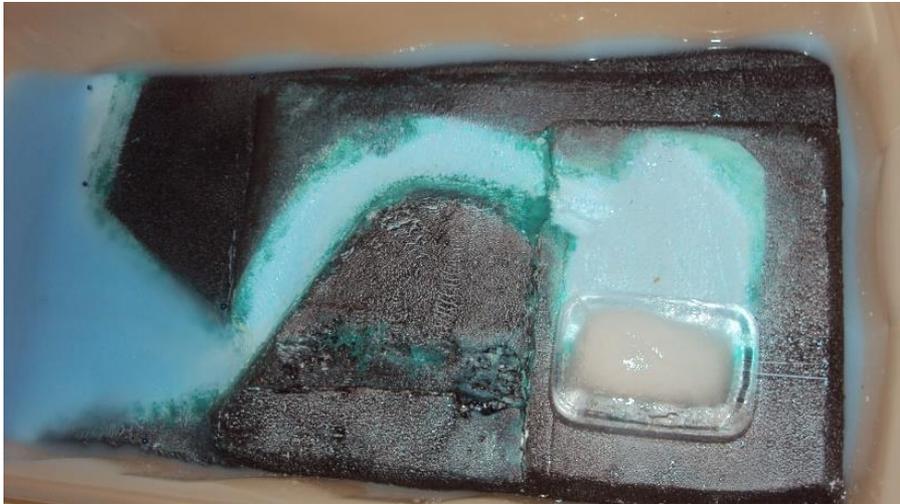
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In the guidelines for the development of the PowerPoint presentation, students were asked to summarize all the phases of the research work developed to stimulate reflection. The evaluation instruments were reapplied to verify if there was an evolution throughout the investigative process (EVALUATION).

# Learning Strategy

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## Integration with other investigative activities



### Investigative Activity

"The sea level is rising!"



### ELABORATION

<https://www.youtube.com/watch?v=MleTg9GfFlw>  
International Teachers' Climate Change Forum

# Learning Strategy

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## Integration with other investigative activities



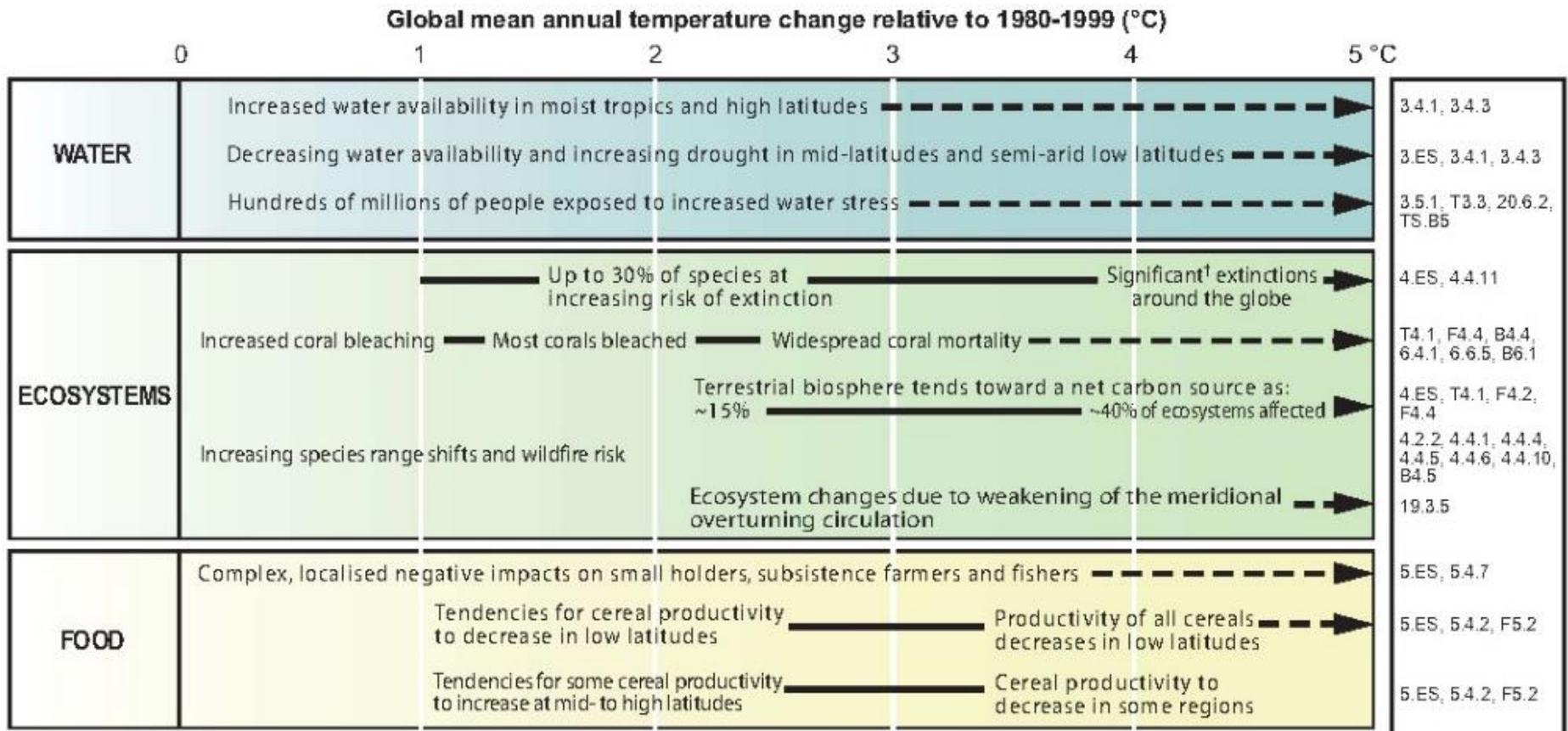
Investigative Activity “Is the Earth a greenhouse?”

# Learning Strategy

## Integration with other investigative activities

### Key impacts as a function of increasing global average temperature change

(Impacts will vary by extent of adaptation, rate of temperature change, and socio-economic pathway)



# Learning Strategy

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In another follow-up lesson, the group completed the conceptual map about the Botanical Garden integrating the different contributions of the work developed by the groups (EVALUATION).

Finally, the students performed a reflection about the set of activities which was subjected to a content analysis (EVALUATION).

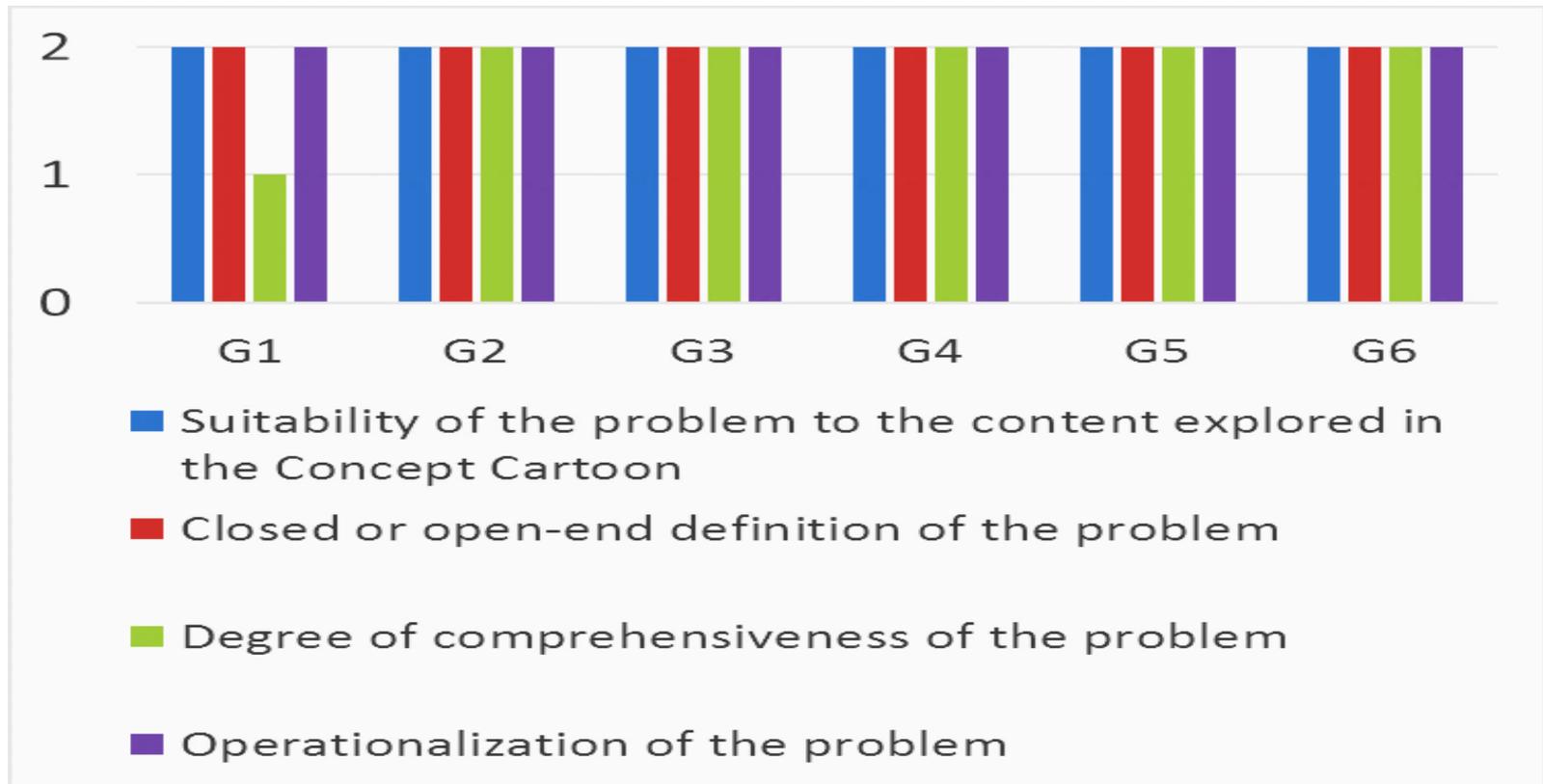
# Evaluation of the Inquiry-based Fieldtrip

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In the engagement phase, the students showed great interest in the use of CC as triggers for the formulation of open and resolvable problems in the existing conditions. In this capacity, only one group posed a less comprehensive problem.

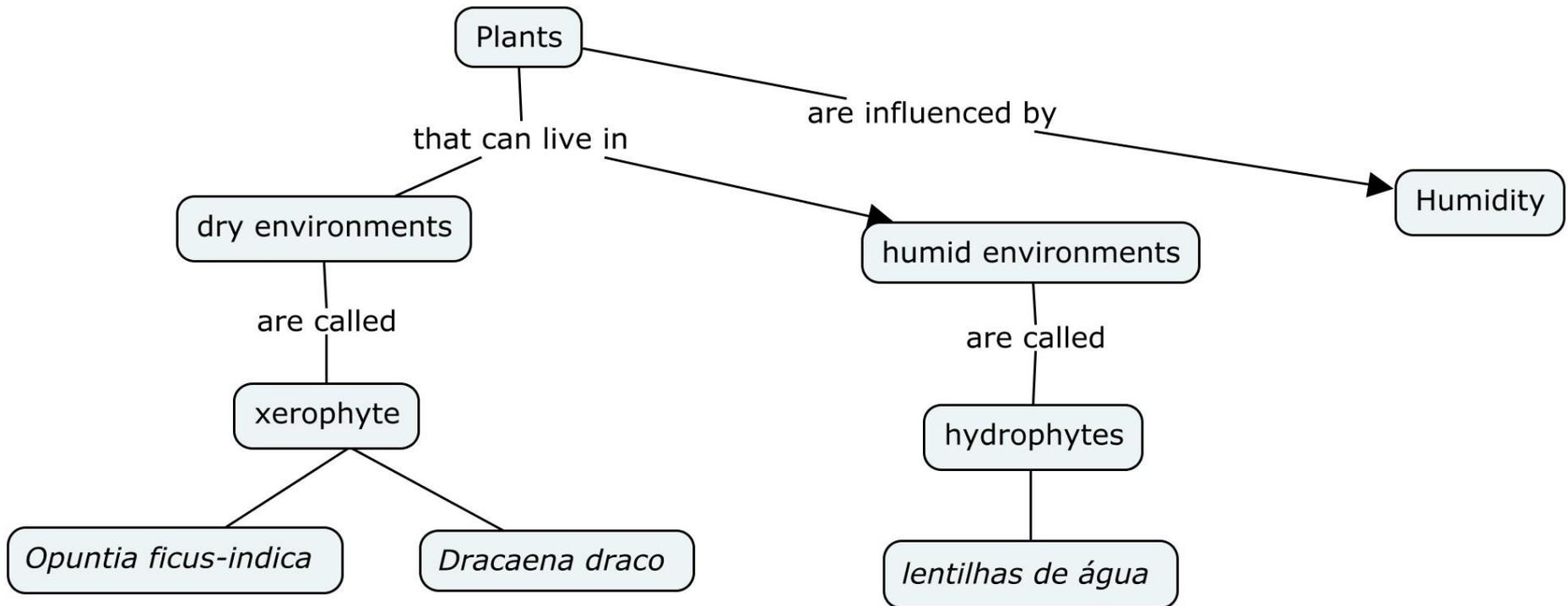
The construction of the initial conceptual map allowed the understand of students' previous ideas, and the final one functioned as a structuring, integrating and synthesis element of data and their analysis.

# Evaluation of the Inquiry-based Fieldtrip



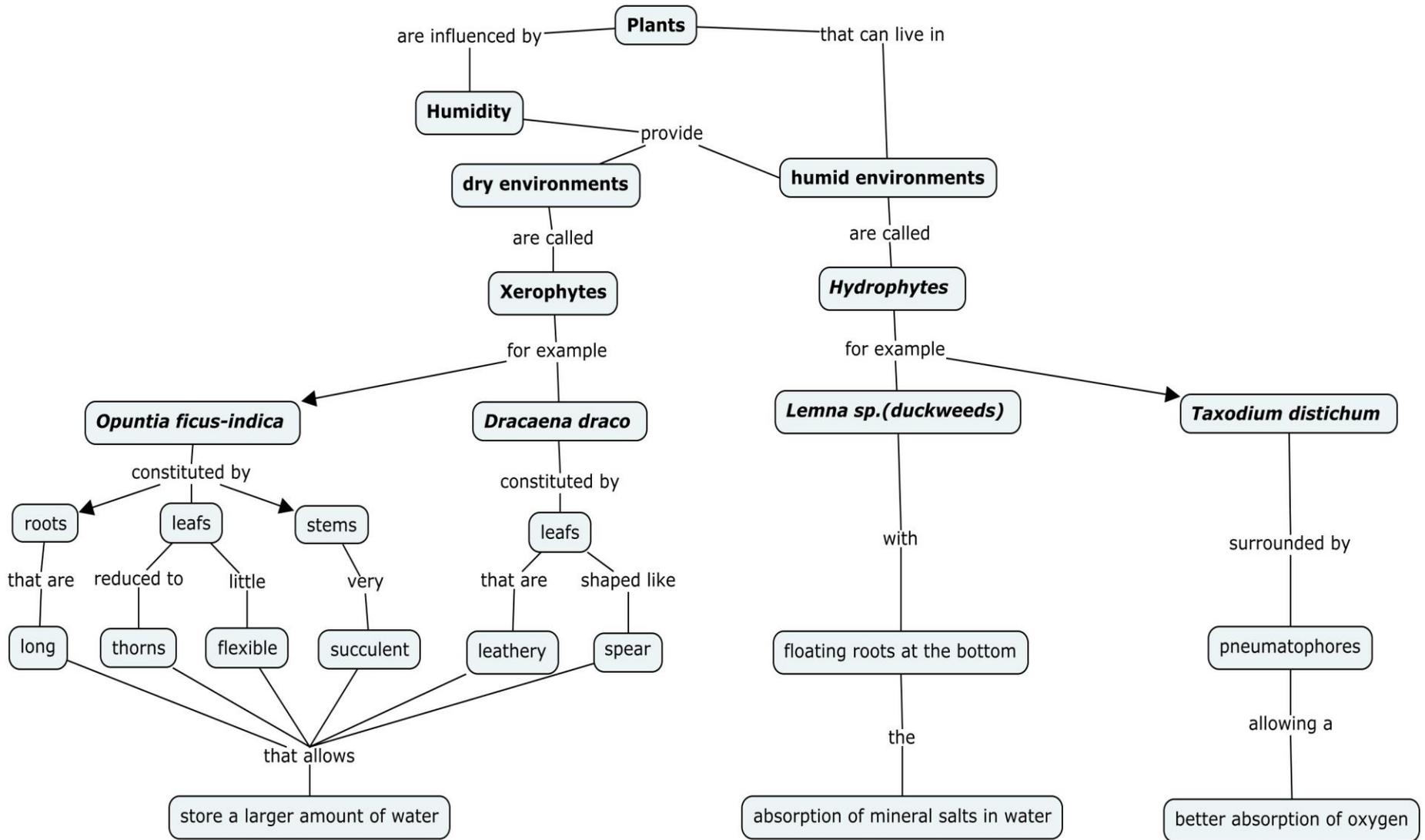
Results of the application of the checklist to assess the definition of the research problem

# Evaluation of the Inquiry-based Fieldtrip



Initial conceptual map of group 4 that studied the adaptations to different humidity conditions

# Evaluation of the Inquiry-based Fieldtrip



Final conceptual map of group 4 that studied the adaptations to different humidity conditions

# Evaluation of the Inquiry-based Fieldtrip

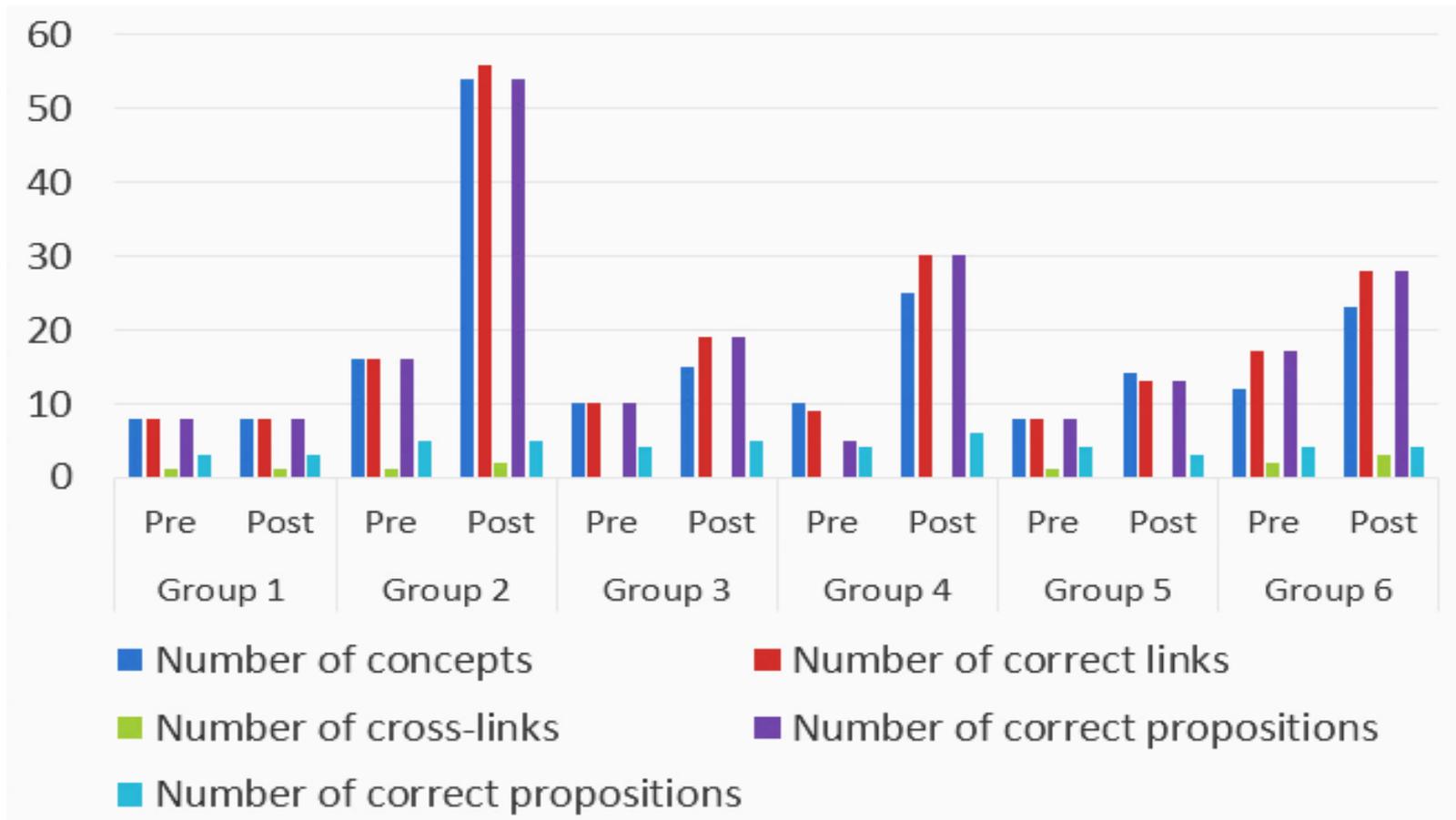
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The groups that presented the most complex final conceptual map were those who did a more detailed and structured analysis and discussion of the results.

The evaluation of the pre and post-visit conceptual maps of each group was carried out based on a quantitative analysis, with an increase in concept numbers, correct links, cross-links, correct prepositions and hierarchical levels.

It was also verified that the number of cross-links presented was reduced and that group 1 presented the post conceptual map equal to the pre, even after receiving the formative feedback.

# Evaluation of the Inquiry-based Fieldtrip



Results of the application of the quantitative analysis grid of conceptual maps

# Evaluation of the Inquiry-based Fieldtrip

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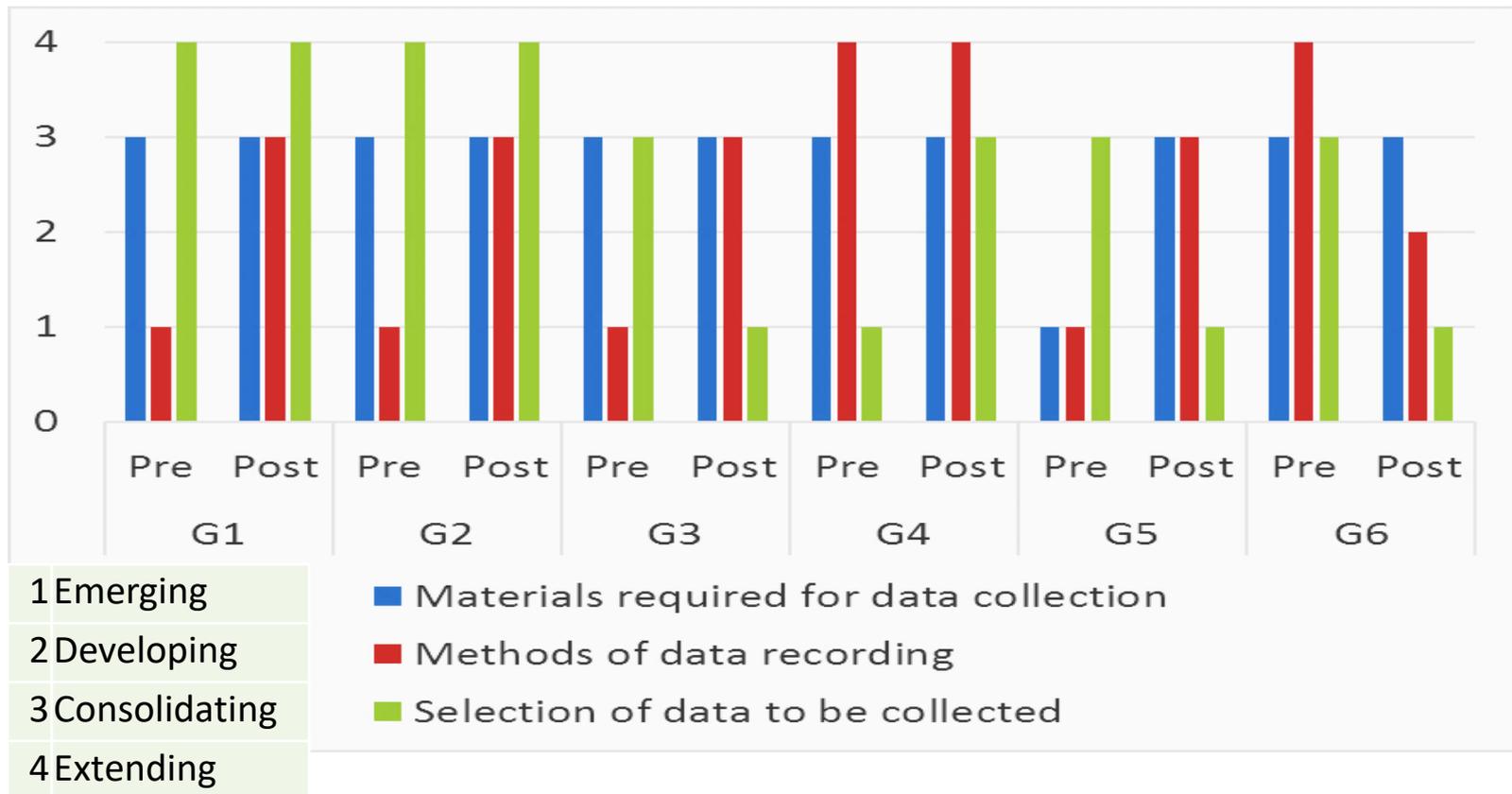
The planning phase allowed students to reflect on the investigation they would carry out, allowing greater autonomy in the LBG.

The groups identified the materials needed for data collection, including writing materials and cameras.

Regarding the methods of data recording, four groups did not explain them in the initial planning, and explained them in the communication of their research.

With regard to the selection of data to be collected in order to respond to the problem, several groups did not make it explicit either initially or in the final presentation.

# Evaluation of the Inquiry-based Fieldtrip



Results of the application of the rubric to assess the planning of the research

# Evaluation of the Inquiry-based Fieldtrip

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During the visit, the students took notes and photographs of the plants and the information boards.

Some groups did not select the information according to the defined problem.

The students were very committed and motivated in the accomplishment of this work.

# Evaluation of the Inquiry-based Fieldtrip

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The organization, treatment and descriptive analysis of the data were carried out adequately by all groups.

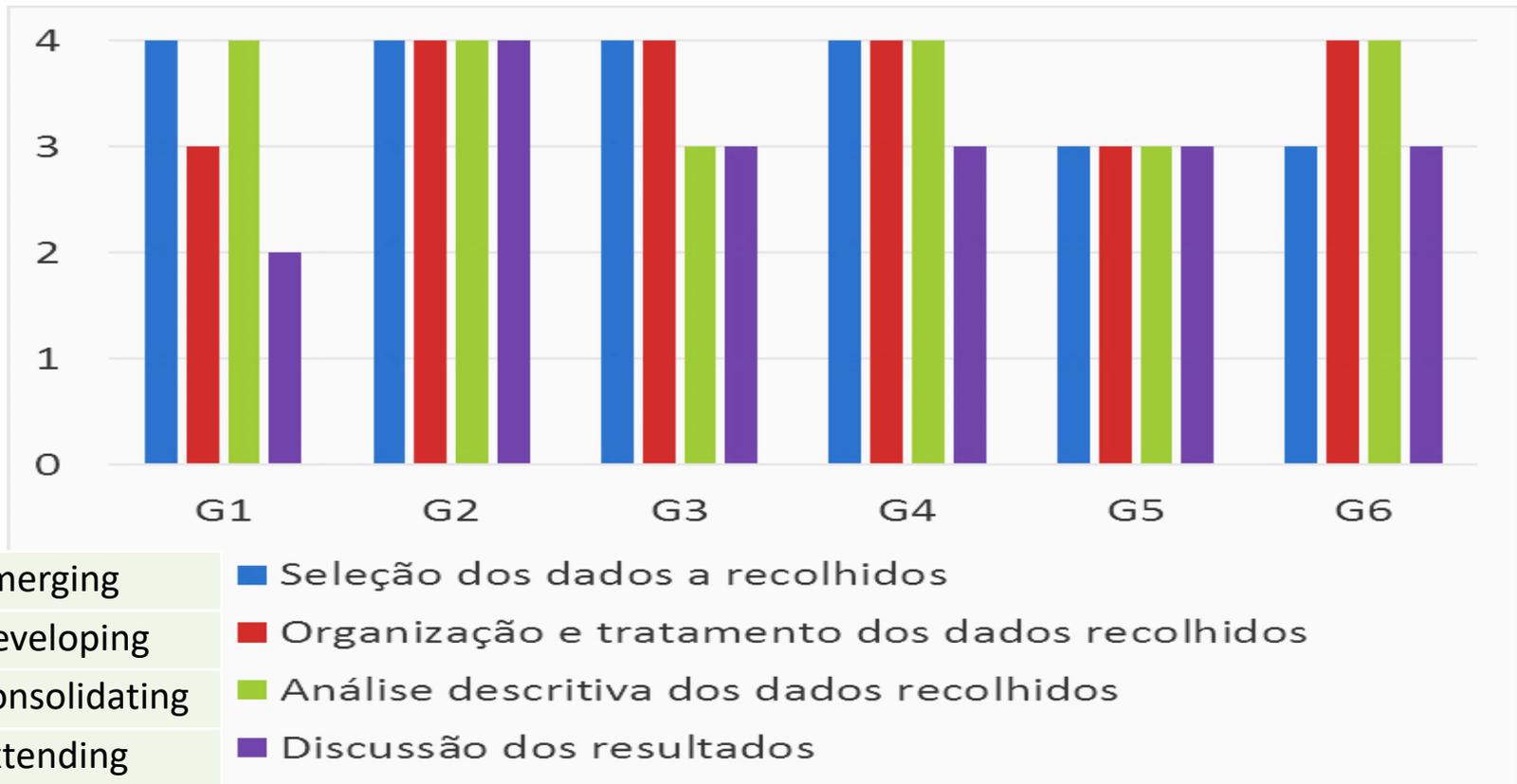
The presentation of the research was prepared by students outside the classroom and the groups delivered the first versions of the PowerPoint presentations via electronic mail.

Several aspects that needed to be improved were found, in particular the failure to comply with the instructions previously provided.

One group presented the results without selecting the data collected according to the problem.

In this feedback suggestions were provided and students improved various aspects of the PowerPoint presentation of their investigations.

# Evaluation of the Inquiry-based Fieldtrip



Results of the application of the rubric to assess the analysis and treatment of research data

# Evaluation of the Inquiry-based Fieldtrip

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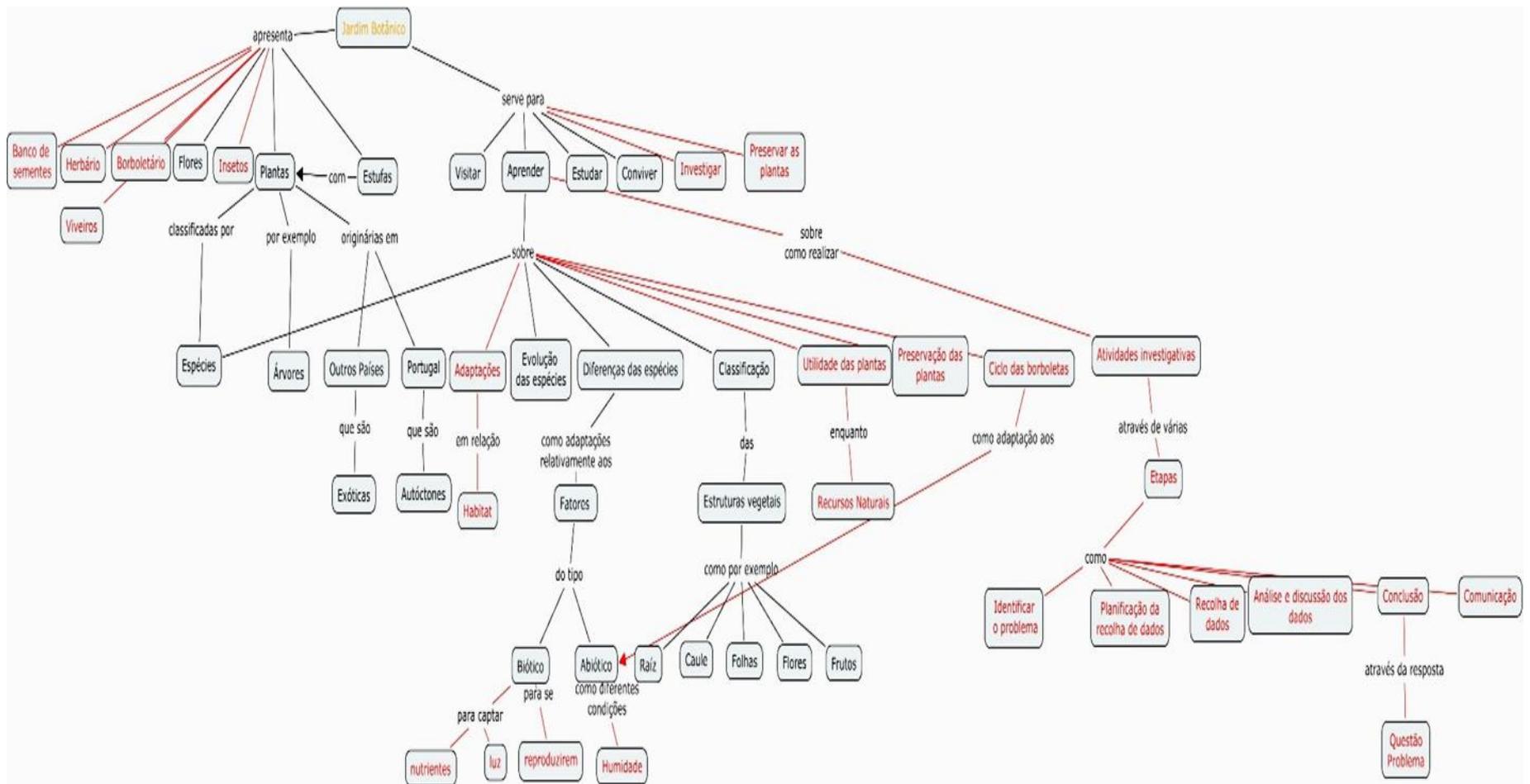
Although the works presented were very rich, the discussion of the results was limited in some aspects.

For this may have contributed the lack of argumentative skills of some students in the class, already detected in the application of other inquiry-based activities.

In another follow-up lesson, the class as a whole completed the final conceptual map about the Botanical Garden which allowed the integration of the groups investigations' carried out throughout the activity.

In this conceptual map, the main phases of the research were again focused and other functions of a botanical garden were introduced that the students did not have access to during the visit, such as the herbarium and the seed bank.

# Evaluation of the Inquiry-based Fieldtrip



Final conceptual map in IHMC CmapTools developed in the ICT class based on the following questions:

- What is a Botanical Garden?
- What is the use of a Botanical Garden?

# Evaluation of the Inquiry-based Fieldtrip

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To conclude the application of this activity students were asked to carry out an individual reflection based on the following questions:

- "What is a Botanical Garden and what is it for?";
- "What did you learn about the issue you investigated?";
- "Identify the phases of your investigative work.";
- "What did you like most / least about the activity?".

The reflections of the students were subjected to a content analysis.

# Evaluation of the Inquiry-based Fieldtrip

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Concerning the question, "**What is a Botanical Garden and what is it for?**", 21 students identified the botanical garden as a space with plants, but some students also talked about animals including butterflies.

The students also identified the spaces in the botanical garden. 5 students referred to the greenhouse, 4 the butterfly house and 3 the laboratory.

19 students identified the botanical garden as a space to learn/study and 18 as a place to promote the conservation of species.

Some students also mentioned other activities that can be done in the botanical garden, for example: investigate; observe; visit; planting plants; space of leisure and space of culture.

# Evaluation of the Inquiry-based Fieldtrip

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Concerning the question, **"What did you learn about the issue you investigated?"**:

- 20 students identified the work theme;
- 17 students listed what they learned;
- 15 students made a generalization of the learning about the theme;
- 5 students presented examples about the species they investigated.

# Evaluation of the Inquiry-based Fieldtrip

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With regard to the question, "**Identify the phases of your investigative work.**", the phases identified by the students were:

- identification of the problem by 16 students;
- planning of data collection by 12 students;
- data collection by 28 students;
- organization and processing of data by 13 students;
- analysis and discussion of the results by 14 students;
- solve the problem by 15 students;
- communication by 8 students.

# Evaluation of the Inquiry-based Fieldtrip

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It is also worth noting that although the students have reflected several times about the phases of their investigative work, only 10 students have been able to do a detailed description of these phases, 11 students describe them partially and 7 students describe less than three phases of the investigative work.

This was a difficulty identified earlier. Students find difficult to understand questions of the nature of science and undervalue epistemological scientific knowledge when compared to declarative and procedural scientific knowledge, despite continuous valuation throughout the academic year, whether in learning activities or in evaluation tests.

# Evaluation of the Inquiry-based Fieldtrip

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In the question, "**What did you like the most about the activity?**", there was a great dispersion of responses.

From the students' answers, the new learning about the plants, was referred by 7 students and to search plants in the LBG with a map, was mentioned by 4 students.

The students enjoyed doing the investigation in the botanical garden autonomously. Two students referred that they felt the experience as a kind of adventure.

One student made reference to the similarity of the work developed with the one of the scientists.

# Evaluation of the Inquiry-based Fieldtrip

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The response of two students is given below as example.

"What I liked most was to find the plants with the map alone with my colleagues and take pictures of the plants."

Student 2

"What I liked most was when we went to the garden and search the plants, because we looked like real scientists, especially in the rain."

Student 15

# Evaluation of the Inquiry-based Fieldtrip

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On the question **“What did you like least in the activity?”**,

- 8 students reported the fact that was raining;
- 6 students mentioned having nothing to point out;
- 4 students identified the realization of the conceptual map;
- 4 students indicated the processing/organization of data.

# Conclusion

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In conclusion, the development of activities that promote active learning allow the development of a broader range of investigative skills, such as:

- Diagnose problems;
- Planning and carrying out investigations;
- Analyse data;
- Search for information;
- Communicate;
- Work in group.

# Conclusion

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Taking into consideration the acquired experience with the implementation of this inquiry-based activity, it is recommended that students develop investigative skills in other contexts (experimental, socioscientific issues, decision-making activities, etc.).

In particular, the quality of planning the investigation in the LBG is crucial, facilitating the autonomous work of students who, because of the size of the garden, have limited access to teacher guidance.

# Conclusion

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A careful pre-visit preparation by the teacher and a constant feedback during the implementation of activities are considered fundamental, taking on a tutorial role, monitoring and questioning the students during their inquiry-based work.

The feedback provided promotes the improvement and evolution of learning, encouraging the engagement, autonomy and creativity of student in the learning process (Harlen, 2007).

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**Gonçalo Nuno Carreira Pereira**

Escola Profissional de Ciências Geográficas, Lisboa

[goncalobarreiro@gmail.com](mailto:goncalobarreiro@gmail.com)

**Helena Moita de Deus**

Agrupamento de Escolas Amadora Oeste, Amadora

[hagmmdd@gmail.com](mailto:hagmmdd@gmail.com)

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