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Effects of Spider Concept Mapping Strategy on Performance and Attitude in Ecology Concept among secondary school students in Katsina State, Nigeria

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Abstract

Effective teaching strategies, such as concept mapping, play a crucial role in boosting academic performance and students' attitudes in biology. While concept mapping is known to aid understanding of complex topics such as ecology, little research has examined the specific impact of the spider concept mapping strategy in Nigerian secondary schools, particularly in Katsina State. This study examined the effect of the Spider Concept Mapping Strategy on students' performance and attitude toward ecology concepts among secondary school students in Katsina State, Nigeria. Four null hypotheses were formulated and tested at the 0.05 level of significance. The research adopted a pretest, posttest, quasi-experimental design with a control group. A total of 135 Senior Secondary School II (SSS II) biology students, randomly selected from two schools within the Katsina Zonal Education Quality Assurance, participated in the study. Data were collected using the Ecology Performance Test (reliability coefficient = 0.84) and the Ecology Attitude Scale (reliability coefficient = 0.82). The data were analyzed using Analysis of Covariance (ANCOVA). Findings revealed a significant main effect of treatment on students' performance in biology [$F(1,129) = 4.300; p < 0.05$], indicating that the spider concept mapping strategy effectively enhanced students' achievement. However, no significant main effect of treatment was found on students' attitude toward ecology [$F(1,129) = 1.918; p > 0.05$]. Similarly, gender had no significant main effect on students' performance in ecology [$F(1,129) = 0.945; p > 0.05$], suggesting that male and female students performed comparably.

Keywords: Spider Concept mapping; Performance; Attitude; Gender

Introduction

The persistent decline in students' performance in science subjects has become a major educational concern, demanding urgent intervention. In light of this, science educators need to seek suitable ways of tackling the current mass failure if they are to halt the drift of students to arts and social science subjects (Shaibu, 2020). This is particularly critical for biology, whose relevance among science subjects and its vital role in economic development, from healthcare to agriculture and environmental sustainability, cannot be overemphasized. Given the critical role of biology in academic and professional success, effective teaching of the subject in secondary schools is essential. Improved instructional methods can enhance students' performance in both internal and external examinations, thereby increasing their chances of securing admission into higher institutions. However, traditional teaching approaches, such as lectures, laboratory sessions, and recitations, are increasingly being recognized as insufficient (Skipper & Mintzes, 2023). These methods often prioritize passive learning over active engagement, limiting students' ability to master and retain key



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concepts. Moreover, they rarely cultivate critical thinking, creativity, or the ability to make meaningful connections (Salomi, Alexander, & Louis, 2021). The growing recognition of conventional teaching methods' limitations has prompted biology educators to adopt more effective, student-centered approaches. This pedagogical shift is especially important for teaching challenging topics like ecology, which is a core component of the biology curriculum. Ecology, derived from the Greek words "oikos" (house) and "logos" (study), represents a fundamental topic in biology that examines organisms in their environments (Odaibo, 2022). As Ajaja (2021) explains, this area of biological study focuses on both the structure of nature and the relationships between organisms and their surroundings. Many students struggle with ecological concepts due to their abstract and systems-oriented nature.

The spider concept mapping strategy offers particular benefits for teaching ecological concepts in biology. With its distinctive web-like structure, this visual tool places a central ecological concept at the core, surrounded by related biological principles (Martins et al., 2021). This format helps students organize complex ecological information while maintaining clear connections to broader biological knowledge. Multiple studies (e.g., Novak & Cañas, 2008; Nesbit & Adesope, 2013) have demonstrated that concept mapping strategies significantly enhance student performance in ecological topics within biology. Academic performance, operationally defined as students' ability to both recall key ecological concepts and apply them to biological problems (Shabani, 2020), shows measurable improvement when these visual tools are implemented, particularly for complex systems thinking required in ecology (Wu et al., 2021). Specifically, spider concept maps help students: (1) systematically organize trophic relationships and energy flow patterns, (2) visualize connections between abiotic factors and species distribution, and (3) transfer these ecological principles to broader biological contexts like evolution and adaptation (Yeh et al., 2020). However, as shown in recent meta-analyses (Schroeder et al., 2018), while cognitive gains are significant, affective factors including students' interest in ecological applications and self-efficacy in solving ecological problems remain crucial mediators of long-term knowledge retention. Attitude, described by Adesoji (2021) as a stable pattern of beliefs, emotions, and behaviors, plays a crucial role in learning ecological concepts. Its three components, affective (feelings about ecology), behavioral (application of ecological knowledge), and cognitive (understanding of ecological principles), collectively influence how students engage with this biological topic. When supported by visual strategies like concept mapping, positive attitudes can enhance ecological learning within the biology curriculum.

Statement of the Problem

Ecology is an essential component of the secondary school biology curriculum, helping students understand interactions between organisms and their environment. However, students frequently display poor academic performance and negative attitudes toward ecology concepts, which has been linked to traditional teacher-centered methods that emphasize rote memorization over active engagement (Novak & Cañas, 2008; Okeke, 2016). In Nigeria, especially in northern states like Katsina, studies have shown that many students struggle to retain ecological knowledge and often perceive the subject as abstract and difficult (Adebisi & Yusuf, 2019; Garba, 2020). Research indicates that learning strategies that promote active participation and meaningful organization of information can improve students' understanding and attitudes toward science subjects. One such strategy is the Spider Concept Mapping Strategy (SCMS), which involves creating a central concept connected to sub-concepts through branches, allowing students to visualize relationships and organize knowledge hierarchically (Novak, 2010; Agbaje & Afolabi, 2018). While studies in other Nigerian states suggest that concept mapping improves students' performance and retention in biology (Owolabi & Akinola, 2017), there is limited empirical evidence on the effectiveness of SCMS



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on students' performance and attitudes in ecology, specifically in Katsina State. The lack of research in this context means that secondary school teachers often continue using conventional methods that may not engage students effectively or foster positive attitudes toward ecology. Consequently, students' underperformance and negative attitudes persist, affecting not only academic achievement but also the development of environmentally responsible citizens (UNESCO, 2019). Therefore, this study seeks to investigate the effects of the Spider Concept Mapping Strategy on performance and attitude in ecology among secondary school students in Katsina State, Nigeria, providing evidence for innovative teaching practices that enhance learning outcomes.

Objectives of the study

The main objective of this study is to determine the effect of the spider concept mapping strategy on the performance and attitude of students toward ecology concepts among secondary school students in Katsina State. Specifically, the study aimed to:

1. Determine the main effect of treatment on secondary school students' performance in ecology
2. Find out the main effect of treatment on secondary school students' attitudes toward ecology
3. Investigate the main effect of gender on secondary school students' performance in ecology
4. Access the interaction effect of treatment and gender on secondary school students' performance in ecology

Hypotheses

The following null hypotheses were generated for the study:

- H₀₁: There is no significant main effect of treatment on secondary school students' performance in ecology
- H₀₂: There is no significant main effect of treatment on secondary school students' attitudes toward ecology
- H₀₃: There is no significant main effect of gender on secondary school students' performance in ecology
- H₀₄: There is no significant interaction effect of treatment and gender on secondary school students' performance in ecology

Methodology

The study employed a quasi-experimental pretest-posttest design with non-randomized, nonequivalent control groups to examine the effects of the spider concept mapping strategy on students' academic performance and attitudes in ecology. Participants were divided into two groups: an experimental group taught using the spider concept mapping approach and a control group instructed through conventional methods. Both groups underwent a pretest to assess their baseline knowledge and attitudes before the intervention. Following the treatment period, a post-test was administered to evaluate the impact of the instructional strategies. The target population consisted of all Senior Secondary School Two (SS II) students under the Katsina Zonal Education Quality Assurance in Katsina State. From this population, a sample of 135 students was drawn from selected coeducational schools, with four single-gender schools excluded to maintain consistency. The participating schools were chosen randomly from a list of 22 institutions, while intact classes within these schools were purposively selected to ensure uniformity in student groupings. Data collection relied on two primary instruments: the Ecology Performance Test (EPT) and the Ecology Attitude Scale (EAS). The EPT, adapted from past WAEC and NECO examination questions (2015–2020), comprised 30 multiple-choice items with one correct answer and three distractors per question. The EAS, designed to measure students' attitudes toward ecology, featured a four-point Likert scale (Strongly Agree to Strongly Disagree) with predominantly closed-ended items.



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To ensure the instruments' reliability, a pilot test was conducted in a coeducational school not included in the main study. The EPT's reliability was assessed using the Pearson Product-Moment Correlation Coefficient (PPMC), yielding a value of 0.84, indicating strong consistency. For the EAS, Cronbach's Alpha was employed due to its suitability for Likert-scale instruments, resulting in a reliability coefficient of 0.82, confirming internal consistency. Data collection began with the administration of pretests in the first week to establish students' initial understanding of ecological concepts. The intervention phase spanned four weeks (weeks 2–5), during which the experimental group received instruction via spider concept mapping, while the control group followed conventional teaching methods. The researcher conducted all sessions to maintain consistency in delivery. Post-tests were then administered to both groups to measure changes in performance and attitudes, providing quantitative data for analysis. This structured approach ensured methodological rigor while allowing for a clear comparison between the two instructional strategies.

Presentation of Results

The following null hypotheses were tested at the 0.05 level of significance:

Hypothesis One

There is no significant main effect of treatment on secondary school students' performance in ecology.

Hypothesis Two

There is no significant main effect of treatment on secondary school students' attitudes toward ecology.

Hypothesis Three

There is no significant main effect of gender on secondary school students' performance in ecology.

Hypothesis Four

There is no significant interaction effect of treatment and gender on secondary school students' performance in ecology.

Table 1:

ANCOVA of the Effect of Treatment and Moderating Variables on Students' Performance and Attitude in Ecology

Source	Type III Squares	Df	Mean Square	F	Sig.
Corrected Model	743.171 ^a	5	148.634	14.479	.000
Intercept	1118.332	1	1118.332	108.939	.000
Pretest	7.550	1	7.550	.735	.393
Treatment	44.144	1	44.144	4.300	.040
Attitude	19.693	1	19.693	1.918	.168
Gender	9.698	1	9.698	.945	.333
Treatment * Gender	9.398	1	9.398	.915	.340
Error	1324.266	129	10.266		
Total	58535.000	135			
Corrected Total	2067.437	134			

***Significant (p < 0.05)**

Hypothesis One: Table 1 indicates that treatment had a significant main effect on students' performance in ecology, $F(1,129) = 4.300, p < 0.05$. The null hypothesis is therefore rejected, implying that the Spider Concept Mapping Strategy significantly improved students' performance in ecology.



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Hypothesis Two: The result shows that treatment did not have a significant main effect on students' attitude toward ecology, $F(1,129) = 1.918, p > 0.05$. The null hypothesis is thus retained, suggesting that the Spider Concept Mapping Strategy did not bring about a significant change in students' attitudes.

Hypothesis Three: As shown in Table 1, gender had no significant main effect on students' performance in ecology, $F(1,129) = 0.945, p > 0.05$. The null hypothesis is therefore retained, indicating that both male and female students performed comparably in ecology.

Hypothesis Four: The result further reveals that the interaction between treatment and gender was not significant, $F(1,129) = 0.915, p > 0.05$. The null hypothesis is therefore retained, implying that the effect of the Spider Concept Mapping Strategy on performance was similar for both male and female students.

Table 2

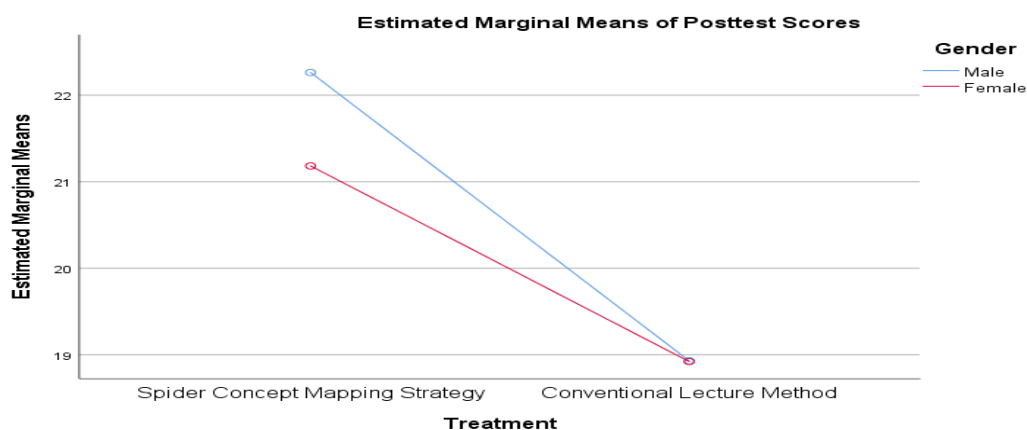
Univariate Tests of the Mean Scores of the Two Groups

	Sum of Squares	Df	Mean Square	F	Sig.
Contrast	44.144	1	44.144	4.300	.040
Error	1324.266	129	10.266		

***Significant ($p < 0.05$)**

The two-way interaction effect of treatment and gender does not affect students' performance in ecology [$F_1, 129 = .915; p > 0.05$]. Since the main effect of treatment is significant but the interaction effect with gender is not significant, it means that the treatment does not depend on gender to be effective. In other words, the treatment is not gender sensitive and will be effective irrespective of students' gender. In summary, all the null hypotheses are being retained except hypothesis one, which states: there is no significant main effect of treatment on students' performance in ecology. In Table 2, there is a significant difference in the students' mean scores between the two groups: the spider concept mapping strategy and the conventional lecture group [$F_1, 129 = .040; p < 0.05$]. Thus, students performed significantly at different levels in the two groups. This indicated that the students taught using the spider concept mapping strategy performed better than those exposed to the conventional lecture method.

The findings in Tables 1 and 2 above are graphically presented in Figure 1 as follows: In Figure 1 below, the spider concept mapping strategy is the best strategy for teaching ecology. Besides the lecture method, male students performed better than female students. However, the difference in male and female students' performance is not significant according to the presentation in Table 1, which indicates that gender alone has no significant effect on students' performance.



Covariates appearing in the model are evaluated at the following values: Pretest scores = 9.38, Attitude = 37.90



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F 1: Mean Plot of the Interaction Effect of Treatment and Gender.

Discussion of Findings

The analysis and results of this study showed that the spider concept mapping strategy brought about the most significant change in the performance of students. This might be due to the visual diagrammatic presentation and friendliness that the strategy provided for the students. Students in the spider group were better motivated to learn. Furthermore, the spider concept mapping strategy yielded a significant difference when compared with the conventional teaching method. The lecture method is the most widely used form of presentation and may be combined with other teaching strategies to give added meaning and direction. The students in this study are conversant with concept mapping as their teachers often used it because of their adaptability to many different settings. Wiseman (2020) gave an illustration of the selection of appropriate teaching methods for a science lesson. Teaching methods should be compared to a maintenance technician's toolbox. The instructor's tools are the teaching methods. Just as the technician uses some tools more than others, there will be times when a less-used tool will be the exact instrument needed for a particular situation. The instructor's success is determined to a large extent by the ability to organize materials and to select and utilize teaching methods most appropriate to a particular lesson. In selecting teaching methods and strategies for a science class, Ajaja (2021), the teacher/instructor considers the following factors: enjoined

- i. The learners' age, their previous knowledge on the topic, and their ability.
- ii. The method should be suitable for the topic being taught.
- iii. The science teacher should select the method he/she can effectively handle.
- iv. The time the lesson will take place.
- v. The size of the class where the lesson is being taught.
- vi. The resources that are at the disposal of the teacher.

Thus, the fact that a method is suitable for the teaching of ecology does not mean it will be a suitable topic for teaching another topic, even in the same subject. There are times a biology teacher may need to combine different methods to teach a particular topic. Omoniyi (2021) identified methods that can be used to teach science effectively. These methods include concept mapping, peer-tutoring, individualized, field-trip method, and computer-based instruction.

Conclusion

Spider concept mapping strategy has been found challenging, but can be evaluated as a rewarding exercise and an overall success as a result of its capability to help the students learn to develop the ability to think critically and analytically. The spider teaching strategy in this paper produces significantly better performance in ecology than the conventional teaching method. Thus, it is an effective mode of instruction for students in secondary schools. However, the findings of this study have revealed that this strategy is the most effective because it allows the students to study on their own. Thus, while making attempts to improve the utilization of the regular school hours of the students, the provision of learning by "doing" could be adequately employed in our classrooms. This paper concludes that the use of the spider concept mapping strategy should be embraced by all senior secondary school science teachers.

Recommendations

Given the results of these findings and the conclusions reached in this paper, the following recommendations are hereby offered:

1. Teachers occasionally should give students topics to relate the concepts, so that after the teacher teaches a new concept, students can link what they learn about the new concept.



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2. Teachers should be encouraged to go for regular workshops and seminars where they can be enlightened on the use of appropriate teaching strategies for different aspects of their subjects.
3. Activity-based learning should be included in the curriculum, thereby engaging and linking all related ideas; this will allow students to relate classroom concepts to real-life situations.

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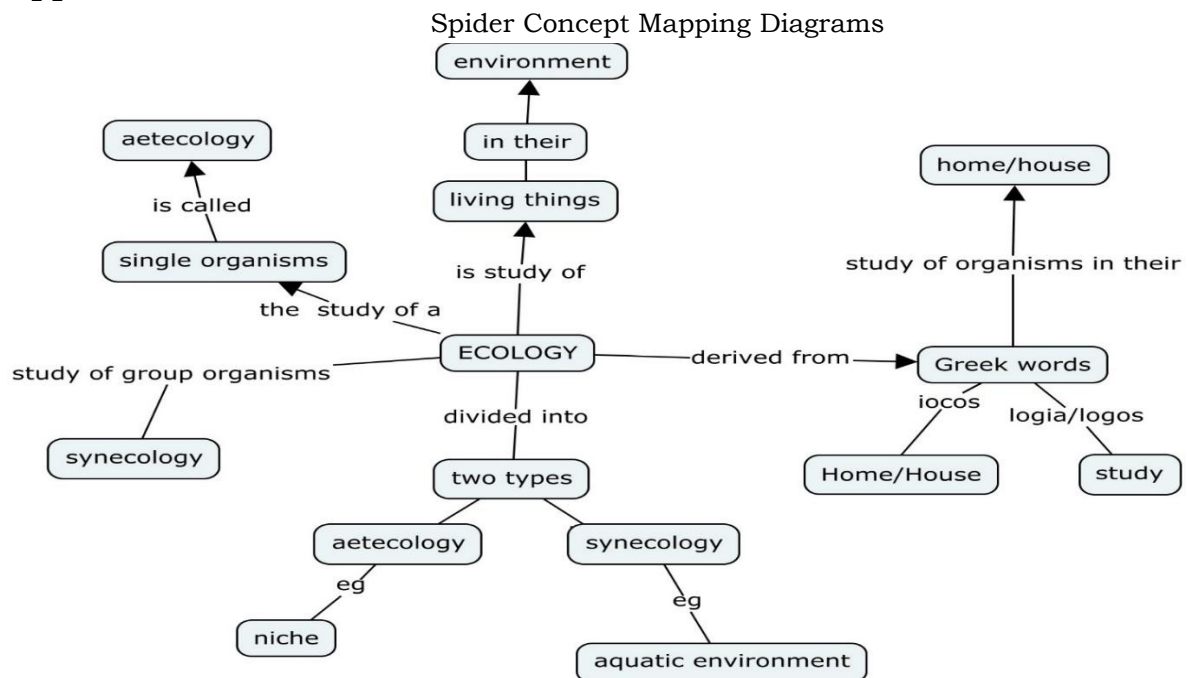
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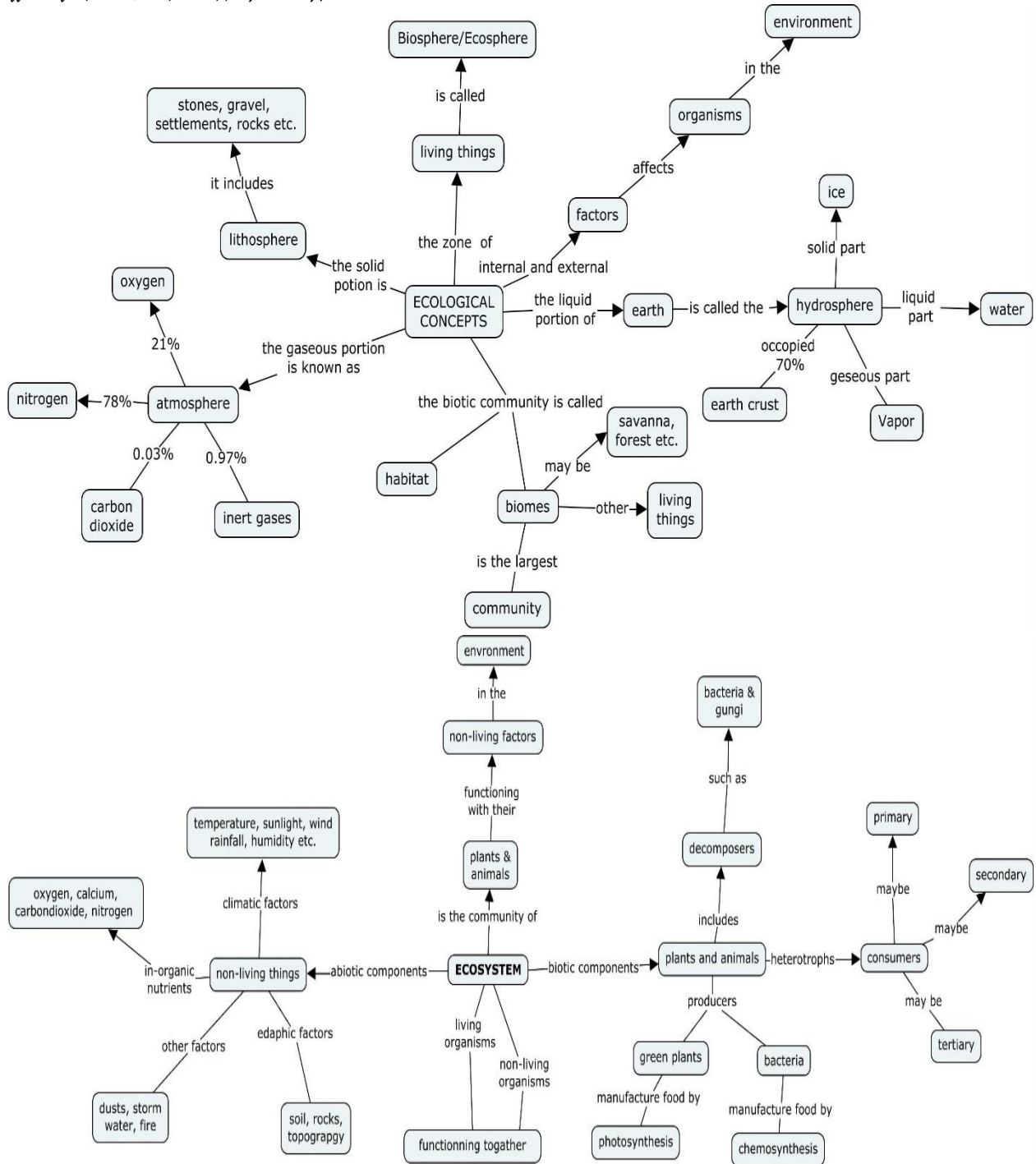
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Appendices



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