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Article

# Plants Are Not Boring, School Botany Is

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**Abstract:** The quality of botanical education depends on the quality and interests of the teacher. The aim of our paper was to conduct an initial study on the attitudes of primary and secondary school teachers about plants and botany. We initiated a study in which 211 biology and 168 teachers of different subjects, from primary to secondary schools in Croatia, participated on a voluntary basis. Statistical analysis was processed using jamovi 2.3 software. Teachers of all profiles (biology and others) had similar attitudes: high opinion about the importance of plants for life and education but not about school botany; botany was in the middle of their scale for potential exclusion from education. The last part of the survey referred only to biology teachers and their interests and suggestions for increasing the attractiveness of botany as a subject. The results showed that botany was the least popular, and within it, teachers were most interested in ecology and horticulture. They suggested that botany would be more interesting with active teaching methods and references to everyday contexts; however, it remains unclear why that is so, as the level of autonomy they are given does enable them to introduce such changes.

**Keywords:** botanical education; Croatia; plant awareness; plant blindness; primary and secondary school teachers



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## 1. Introduction

Teachers are recognized by many as the most important factors affecting the quality of education (e.g., [1]). The quality of education cannot be higher than the quality of the teachers providing it, so the only way to improve outcomes is to improve teaching [2]. We can easily extrapolate these general conclusions by limiting them to a specific subject or topic within that subject, in our case plants and botany. Teachers' work in the classroom can be influenced by many factors, such as familiarity with the content, experience, pedagogy, and finally, their attitude toward a subject, methodology, technology, and the like.

Over the past century, many have repeatedly complained about the low public interest in plants and their insufficient presence in curricula from elementary school to university [3–7], leading to the "extinction of plant education" in the most pessimistic scenarios [8]. The most common rationale for the call to prevent "plant blindness" [7] is the recognition of plants as "amazing organisms" [9] and of their role as key players in some of the most important environmental issues, such as biodiversity loss and climate change [8]. According to researchers, the education system is both one of the causes and one of the solutions to this problem, because ignoring flora can work against the ecological balance and directly hinder the achievement of most of the sustainable development goals [10]. For an overview of the connections between plant blindness and sustainability, we recommend the report by Thomas et al. [11], in which the education system is perceived not as an exclusive but as an important factor for a "greener future". However, there are also concerns about recognising the importance of less popular animals and fighting inequality in the recognition of plants as a means of acknowledging the importance of all living beings [12].

We are not raising the issue of the recognition of 'plant awareness' (the term used in the rest of the text) here [6] as one of the problems facing contemporary biology (botany) education, but rather the inability of educators to find a solution for it. It would be ignorant to say that there have been no attempts to interest children in plants. In fact, there have been many; suggestions have included introducing hands-on activities in the classroom, visits to botanical gardens, encouraging gardening, growing plants, visits to nature, photo hunts, and many others [13–15]. However, given the declining interest in botany, these attempts simply have not worked. Since school is a place where people voluntarily or involuntarily encounter botanical contexts, we believe that change should start there and that both botany content and teaching methods should be reviewed. However, in searching for references, it was found that there was a large research gap, i.e., a lack of references that address the views, opinions, and attitudes of teachers in plant education.

Therefore, the aim of our research was to investigate the attitudes of primary and secondary school teachers about plants and botany, first through a preliminary study in Croatia. The research can be described as exploratory, and no action was taken to change teachers' views. However, inferential statistics and structural equation modelling were used to test certain specific results.

The research questions for which we sought answers, as well as the entire study, can be divided into three main parts:

(a) In the first part, we aimed to answer the following research questions:
   1. What are the teachers' opinions about plant knowledge and botany content in school?
   2. Are there differences between these two areas?
   3. Are there differences between teachers' professional groups?

(b) In the second part of the study, we wanted to know teachers' opinions about their interest in various biological disciplines. The research question we sought to answer was the following:
   4. What biological topics are teachers most interested in, i.e., which contents could be excluded from education?

(c) In the third part of the research, intended exclusively for biology teachers, we asked for opinions that could potentially lead to future solutions for improving school botany. The research questions were the following::
   5. What botanical contents are biology teachers most interested in?
   6. What should be done to make school botany more interesting?

## 2. Materials and Methods

### 2.1. Sample and Sampling

In 2022, an invitation for voluntary participation in the study was sent to all teachers in primary and secondary schools in Croatia. The final sample of teachers who responded to the invitation consisted of 211 (55.7%) biology teachers and 168 (44.3%) teachers of various subjects from elementary to high school (Tables 1 and 2). Among the biology teachers, 156 identified themselves as teachers of biology in elementary school and 55 as teachers working at general or vocational secondary schools.

**Table 1.** Share of biology and other subject teachers who participated in the survey.

| Teaching Profile | Counts | % of Total | Cumulative % |
|---|---|---|---|
| Biology teachers | 211 | 55.7 % | 55.7 % |
| Other teachers | 168 | 44.3 % | 100.0 % |

**Table 2.** Share of all teachers from different schools who participated in the survey.

| Teaching Profile | Counts | % of Total | Cumulative % |
|---|---|---|---|
| Biology teachers Primary school | 156 | 41.2 % | 41.2 % |
| Biology teachers High school | 55 | 14.5 % | 55.7 % |
| Other teachers Primary school | 60 | 15.8 % | 71.5 % |
| Other teachers High school | 52 | 13.7 % | 85.2 % |
| Other teachers Vocational secondary schools | 56 | 14.8 % | 100.0 % |

### *2.2. Methods*

The respondents accessed an online questionnaire that consisted of three thematic units mentioned in the research objectives.

To respond to the first part of the study related to teachers' opinions about the knowledge of plants and the content of plants (botany) in school, an instrument from the study by Šorgo et al. [16] was adapted. The teachers were instructed to answer two questions. They were then asked to read carefully and tick on a scale what they thought of the following items: (a) knowledge about plants; (b) content of botany taught in schools. Identical scales were used in both cases. The adjective pairs used in the study were as follows: boring–fascinating; uninteresting–interesting; unimportant–important; unattractive–attractive; and unexciting–exciting. The range of the items in scales was from "0" to "6" (cf. Table 3).

To answer the second part regarding the importance of biological content in schools, we asked teachers to provide their opinions on which part of biology they would exclude from biology classes on a seven-point scale, from completely disagree ("0") to completely agree ("6") (cf. Table 4).

To answer the research question about what should be carried out to make botany more interesting, three questions with multiple items were offered (cf. Tables 5–7), with a 0 to 6 response format. The possible answers originated primarily from the first hand experiences of the researchers with their biology education, as well as from earlier studies searching for answers on how to make biology (science) more attractive [17].

All calculations were made using jamovi (ver. 2.3) software [18]. The statistical procedures were performed following recommendations in the literature, such as [19–21] and supporting materials from the jamovi (ver. 2.3) software [18].

## 3. Results

### *3.1. Teachers' Opinions about Plant Knowledge and Botany Content in School*

The results of the descriptive analyses of teachers' opinions about plant knowledge and botany content in schools are presented in Tables 3 and 4 and Figure 1.

From the results presented in Table 3 (Cronbach's alpha = 0.903; Eigenvalue = 3.61; % of variance = 74.7) and Table 4 (Cronbach's alpha = 0.912; Eigenvalue = 3.74; % of variance = 72.1), it can be concluded that in all cases teachers gave higher and more positive scores to statements about general knowledge and importance of plants compared to school botany. On average, the highest scores were given to the importance of plants (botany) in both the general and school contexts and the lowest to the attractiveness and appeal of school botany.

The differences between biology teachers and teachers of other subjects were not statistically significant in most cases, and even when they were statistically significant, the differences in terms of effect size ($r_{rb}$ = rank biserial correlation) were non-existent or very small. When comparing opinions between primary and secondary school biology teachers, the mean responses were found to be slightly higher in lower secondary school teachers;

however, the differences were statistically insignificant at the 0.005 level in all cases except for Q2b. Even for Q2b, whether school botany is of interest, the differences were small ($U$ = 3541, $P$ = 0.045; Cohen's $d$ = 0.27).

**Table 3.** Differences in opinions about plant knowledge in school (N = 379) between primary and secondary school biology teachers (bio; $n_{bio}$ = 211; 55.7%) and teachers of other subjects (oth; $n_{oth}$ = 168; 44.3%).

| Code | Subj | Mean | Median | Mode | SD | $U$ | $P$ | $r_{rb}$ |
|---|---|---|---|---|---|---|---|---|
| Knowledge about plants is | | | | | | | | |
| Q1a: boring–fascinating | bio | 4.84 | 5 | 6 | 1.24 | 17,293 | 0.671 | 0.0243 |
| | oth | 4.73 | 5 | 6 | 1.39 | | | |
| | total | 4.79 | 5 | 6 | 1.31 | | | |
| Q1b: uninteresting–interesting | bio | 4.91 | 5 | 6 | 1.25 | 17,313 | 0.683 | 0.0232 |
| | oth | 4.84 | 5 | 6 | 1.33 | | | |
| | total | 4.88 | 5 | 6 | 1.29 | | | |
| Q1c: unimportant–important | bio | 5.19 | 6 | 6 | 1.12 | 17,310 | 0.670 | 0.0234 |
| | oth | 5.13 | 6 | 6 | 1.14 | | | |
| | total | 5.16 | 6 | 6 | 1.13 | | | |
| Q1d: unattractive–attractive | bio | 4.36 | 4 | 6 | 1.40 | 16,886 | 0.417 | 0.0473 |
| | oth | 4.47 | 5 | 5 | 1.36 | | | |
| | total | 4.41 | 5 | 6 | 1.38 | | | |
| Q1e: unexciting–exciting | bio | 4.29 | 4 | 6 | 1.42 | 17,252 | 0.648 | 0.0266 |
| | oth | 4.34 | 5 | 6 | 1.44 | | | |
| | total | 4.31 | 4 | 6 | 1.43 | | | |

$U$ = Mann–Whitney U; $P$ = probability; $r_{rb}$ = rank biserial correlation as a measure of effect size.

**Table 4.** Differences in opinions about botany content in school (N = 379) between primary and secondary school biology teachers (bio; $n_{bio}$ = 211; 55.7%) and teachers of other subjects (oth; $n_{oth}$ = 168; 44.3%).

| Code | Subj | Mean | Median | Mode | SD | $U$ | $P$ | $r_{rb}$ |
|---|---|---|---|---|---|---|---|---|
| The contents of botany that are taught in schools are | | | | | | | | |
| Q2a: boring–fascinating | bio | 3.26 | 3 | 3 | 1.22 | 15,641 | 0.040 | 0.1176 |
| | oth | 3.48 | 3 | 3 | 1.24 | | | |
| | total | 3.35 | 3 | 3 | 1.23 | | | |
| Q2b: uninteresting–interesting | bio | 3.42 | 3 | 3 | 1.20 | 15,694 | 0.047 | 0.1145 |
| | oth | 3.64 | 4 | 3 | 1.32 | | | |
| | total | 3.52 | 3 | 3 | 1.26 | | | |
| Q2c: unimportant–important | bio | 4.31 | 4 | 4 | 1.16 | 17,298 | 0.679 | 0.0241 |
| | oth | 4.22 | 4 | 3 | 1.44 | | | |
| | total | 4.27 | 4 | 4 | 1.29 | | | |
| Q2d: unattractive–attractive | bio | 3.24 | 3 | 3 | 1.18 | 15,570 | 0.035 | 0.1215 |
| | oth | 3.44 | 3 | 3 | 1.36 | | | |
| | total | 3.33 | 3 | 3 | 1.26 | | | |

**Table 4.** *Cont.*

| Code | Subj | Mean | Median | Mode | SD | *U* | *P* | $r_{rb}$ |
|---|---|---|---|---|---|---|---|---|
| Q2e: unexciting–exciting | bio | 3.22 | 3 | 3 | 1.24 | 16,119 | 0.115 | 0.0906 |
| | oth | 3.36 | 3 | 3 | 1.31 | | | |
| | total | 3.29 | 3 | 3 | 1.27 | | | |

*U* = Mann–Whitney U; *P* = probability; $r_{rb}$ = rank biserial correlation as a measure of effect size.

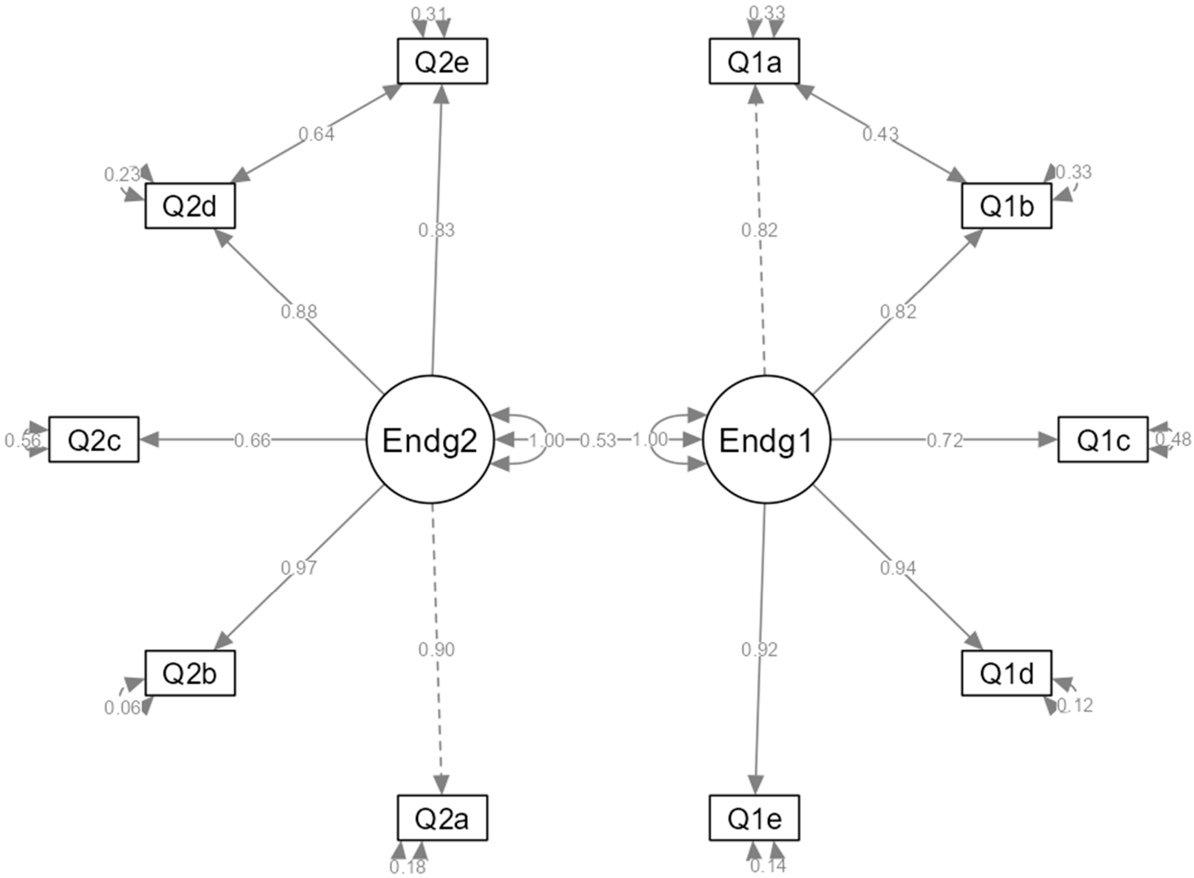


**Figure 1.** A model presenting relations and path coefficients between teachers' opinions about plant knowledge (Endg1) and botany content in school (Endg2); (Q1a, Q2a = boring–fascinating; Q1b, Q2b = uninteresting–interesting; Q1c, Q2c = unimportant–important; Q1d, Q2d, = unattractive–attractive; and Q1e, Q2e = unexciting–exciting).

Based on the minimal differences in opinion between the primary and secondary school biology teachers and teachers of other subjects, we began to build a CFA (confirmatory factor analysis) model. Using this model, a moderate correlation ($r = 0.53$) between the two latent constructs was identified. The model had a reasonable fit (SRMR = 0.053; RMSEA = 0.071 (CI95 = 0.054–0.088); TLI = 0.998). To achieve these fits, constraining was required between error terms of variables Q1a and Q1b in the first latent variable (botany) and Q2d and Q2d in the second latent variable (school botany)

### *3.2. Opinions about the Interest in Various Biological Disciplines and/or Necessity of Exclusion of Biology Contents in Schools*

We continued our study by asking all the teachers to express their (dis)agreement with certain statements asking a question about what should be removed from biology classes in elementary and secondary schools (this followed chapters from curricula). The results are presented in Table 5 and Figures 2 and 3.

**Table 5.** Measures of central tendencies and differences among teachers regarding the statement "If I could, I would remove from the curriculum the subject of nature and biology in elementary and secondary schools". N = 379; biology teachers (bio; $n_{bio}$ = 211; 55.7%), and teachers of other subjects (other; $n_{oth}$ = 168; 44.3%). The results are ordered by increasing the mean on a scale from 0 (completely disagree) to 6 (completely agree).

| Code | Discipline | Teacher | Mean | Median | Mode | SD | *U* | *P* | *r* |
|---|---|---|---|---|---|---|---|---|---|
| Q3a | Human biology | bio | 0.540 | 0 | 0 | 1.44 | 13,519 | <0.001 | 0.2373 |
| Q3e | Ecology | bio | 0.924 | 0 | 0 | 1.58 | 14,547 | <0.001 | 0.1792 |
| Q3b | Cell biology | bio | 0.938 | 0 | 0 | 1.62 | 12,557 | <0.001 | 0.2916 |
| Q3i | Genetics | bio | 1.199 | 0 | 0 | 1.71 | 12,713 | <0.001 | 0.2827 |
| Q3c | Botany | bio | 1.209 | 0 | 0 | 1.71 | 14,798 | 0.003 | 0.1651 |
| Q3a | Human biology | other | 1.214 | 0 | 0 | 1.70 | | | |
| Q3h | Physiology | bio | 1.261 | 1 | 0 | 1.53 | 13,062 | <0.001 | 0.2630 |
| Q3k | Zoology | bio | 1.284 | 0 | 0 | 1.76 | 14,382 | <0.001 | 0.1886 |
| Q3j | Microbiology | bio | 1.507 | 1 | 0 | 1.68 | 11,716 | <0.001 | 0.3390 |
| Q3e | Ecology | other | 1.577 | 1 | 0 | 2.01 | | | |
| Q3f | Evolution of living beings | bio | 1.635 | 1 | 0 | 1.92 | 16,181 | 0.127 | 0.0871 |
| Q3c | Botany | other | 1.643 | 1 | 0 | 1.70 | | | |
| Q3g | Human evolution | bio | 1.730 | 1 | 0 | 1.95 | 17,011 | 0.483 | 0.0403 |
| Q3b | Cell biology | other | 1.804 | 1 | 0 | 1.84 | | | |
| Q3k | Zoology | other | 1.851 | 1 | 0 | 1.84 | | | |
| Q3g | Human evolution | other | 1.857 | 1 | 0 | 1.95 | | | |
| Q3f | Evolution of living beings | other | 1.899 | 2 | 0 | 1.90 | | | |
| Q3i | Genetics | other | 2.042 | 2 | 0 | 1.84 | | | |
| Q3h | Physiology | other | 2.095 | 3 | 3 | 1.78 | | | |
| Q3j | Microbiology | other | 2.565 | 3 | 3 | 1.81 | | | |

*U* = Mann–Whitney U; *P* = probability; $r_{rb}$ = rank biserial correlation as a measure of effect size.

An interesting pattern can be seen when observing Table 5. There are both similarities and differences between biology teachers and teachers of other subjects. From the results obtained, it appears that most biology teachers believe that the content of biology at the subject level should not be cut in such a way that one topic or another is eliminated from the curricula (median = 0) for most of the disciplines, botany included. When it comes to individual topics (Table 6), we can see that biology teachers would sacrifice human anatomy last and human evolution first, and teachers of other subjects would sacrifice microbiology. There was no difference between teachers of all subjects with respect to evolution. Botany basically shares the same group with zoology and is in the middle of the scale in both groups.

**Table 6.** Analysis of biology teachers' interest in various biological disciplines (N = 211).

| Code | Discipline | Mean | Median | Mode | SD | PC1 | PC2 | PC3 |
|---|---|---|---|---|---|---|---|---|
| Q4a | Human biology and anthropology | 5.28 | 6 | 6 | 1.17 | 0.534 | | |
| Q4i | Genetics | 4.98 | 6 | 6 | 1.39 | 0.698 | | |
| Q4h | Physiology | 4.70 | 5 | 5 | 1.24 | 0.456 | | |
| Q4e | Ecology | 4.65 | 5 | 6 | 1.42 | | 0.752 | |
| Q4k | Zoology | 4.65 | 5 | 6 | 1.32 | | 0.682 | |

**Table 6.** *Cont.*

| Code | Discipline | Mean | Median | Mode | SD | PC1 | PC2 | PC3 |
|---|---|---|---|---|---|---|---|---|
| Q4b | Cell biology with molecular biology | 4.62 | 5 | 6 | 1.40 | 0.883 | | |
| Q4j | Microbiology | 4.50 | 5 | 6 | 1.33 | 0.716 | | |
| Q4d | Cytology | 4.24 | 4 | 4 | 1.34 | 0.812 | | |
| Q4c | Botany | 4.19 | 4 | 4 | 1.51 | | 0.806 | |
| Q4g | Human evolution | 4.18 | 4 | 4 | 1.54 | | | 0.956 |
| Q4f | Evolution of living beings | 4.17 | 4 | 4 | 1.46 | | | 0.845 |
| | Cronbach's alpha | | | | | 0.816 | 0.655 | 0.817 |
| | Eigenvalue | | | | | 3.05 | 1.94 | 1.79 |
| | % of variance | | | | | 27.7 | 17.6 | 16.3 |

When biological disciplines are considered a latent variable, according to the reliability analysis (Cronbach's alpha = 0.925) and PCA analysis, all biological disciplines formed a component that explains 59.9% of the variance (eigenvalue = 5.99). A different picture emerges when examining a latent structure by applying EFA with principal axis factoring with oblimin rotation as a tool to extract the factors. Three factors were extracted, explaining 67.2% of the variance (factor loadings are not shown). The first factor (explained variance = 24.9%; Cronbach's alpha = 0.878) groups variables Q3a, Q3b, Q3c, Q3e, and Q3k (Figure 2). The second factor (explained variance = 21.8%; Cronbach's alpha = 0.845) was formed by variables Q3h, Q3i, and Q3j. The final and third factor retained after parallel analysis was an evolution factor formed by Q3f and Q3g (explained variance = 20.5%; Cronbach's alpha = 0.992).

We continued to examine the latent structure of two parallel models using CFA analysis. In the first model (Figure 2), where all items were considered as one variable (Figure 2), the fit indices of the latent variables were SRMR = 0.049; RMSEA = 0.082 ($CI_{95}$ = 0.067–0.099), $P < 0.001$; TLI = 0.995. However, the two variables on evolution (Q2e and Q2f) should be constrained.

The second model is based (Figure 3) on factors extracted by CFA and oblimin rotation. All three factors (latent variables) were highly correlated. However, the model has a superior fit when compared to the model presented in Figure 1. The fit indices of model 2 (Figure 2) are SRMR = 0.037; RMSEA = 0.050 ($CI_{95}$ = 0.031–0.069), $P = 0.465$; TLI = 0.999.

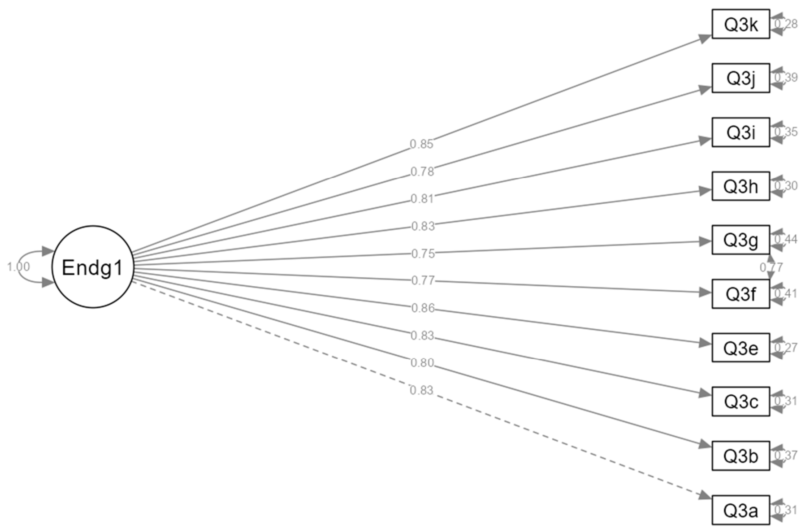


**Figure 2.** Factor loadings of the single factor model related to the teachers' interest in different biological disciplines (codes of the disciplines according to the Table 5).

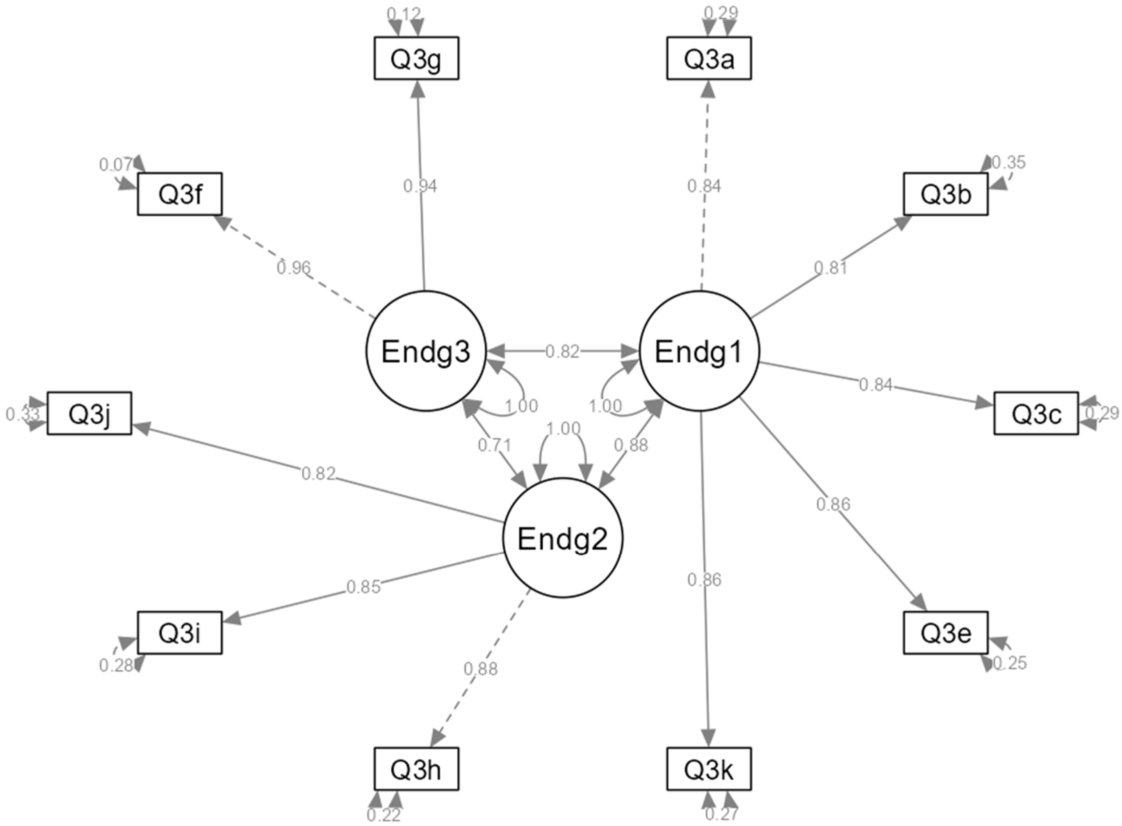


**Figure 3.** Factor loadings and correlations between constructs in the three-factor model related to the teachers' interest in different biological disciplines (codes of the disciplines according to Table 5).

### *3.3. Interests of Biology Teachers and Solutions to Increase the Attractiveness of Botany as a Subject*

In the third part, questions were specifically aimed at biology teachers with a particular interest in botany, so only the responses of biology teachers (N = 211) were included in the analysis (Tables 6–8). In the first section, we asked teachers about their interests in various biological disciplines. Eleven disciplines traditionally included in secondary school curricula were included (Table 6).

**Table 7.** Analysis of biology teachers' interests in different botany contents (N = 211).

| Code | Discipline | Mean | Median | Mode | SD | PC1 | PC2 |
|---|---|---|---|---|---|---|---|
| Q5c | Plant ecology | 4.65 | 5 | 6 | 1.38 | | 0.624 |
| Q5d | Horticulture | 4.56 | 5 | 6 | 1.50 | | 0.843 |
| Q5e | Plant physiology | 4.33 | 5 | 5 | 1.37 | 0.839 | |
| Q5g | Geobotany | 4.23 | 4 | 5 | 1.52 | | 0.769 |
| Q5f | Plant anatomy | 4.12 | 4 | 4 | 1.46 | 0.871 | |
| Q5b | Plant morphology | 4.01 | 4 | 5 | 1.45 | 0.772 | |
| Q5a | Plant systematic | 3.32 | 3 | 3 | 1.71 | 0.479 | |
| | Cronbach's alpha | | | | | 0.779 | 0.681 |
| | Eigenvalue | | | | | 2.45 | 1.90 |
| | % of variance | | | | | 35 | 27.1 |

Based on the analysis of the central tendencies and PCA analysis (Table 6), human biology was at the top of the popularity scale, followed by genetics and physiology. At the end of the line is evolution, both general and human, which form a major component of their own. They are accompanied by botany, which belongs to the more traditional disciplines of zoology and ecology and forms the second principal component. Cumulatively, 61.6% of the variance (Cronbach's alpha = 0.820) can be explained by the scale.

To explore interests of biology teachers in botany contents, they were asked to mark their interest in several botanical disciplines on seven-point scales (Table 7).

From the results presented in Table 7, it can be concluded that, for biology teachers, ecology and horticulture are at the top of their interest, and they form a principal component with geobotany. At the bottom are plant morphology, plant anatomy, and systematics (taxonomy), which can be considered the traditional botanical core curriculum. Cronbach's alpha of the scale is 0.800 and cumulatively explains 62.1% of the variance in two principal components.

When biology teachers were asked how to make botany more interesting (Table 8), two principal components were identified. In the first component, there are items that can be seen as asking for more active strategies, methods, and forms in teaching biology. The second component contains items that deal with the digitalization of teaching and competitions. Cronbach's alpha of the whole scale is 0.821, and 61.6% of the variance can be explained.

**Table 8.** Analysis of teachers' suggestions on how to make school botany more interesting (N = 211).

| | | Mean | Median | Mode | SD | PC1 | PC2 |
|---|---|---|---|---|---|---|---|
| Q6c | Connect teaching content more with everyday life | 5.61 | 6 | 6 | 0.829 | 0.879 | |
| Q6b | Conduct more field classes with workshops in nature | 5.55 | 6 | 6 | 0.901 | 0.922 | |
| Q6a | Carry out more practical work in class | 5.36 | 6 | 6 | 1.035 | 0.826 | |
| Q6g | Add more interesting botanical content in teaching materials | 5.27 | 6 | 6 | 0.969 | 0.621 | |
| Q6d | It is mandatory to involve students in extracurricular activities (flower growers, cooperatives ... ) | 4.83 | 5 | 6 | 1.356 | 0.532 | |
| Q6e | Use more video materials about plants in the lessons | 4.50 | 5 | 5 | 1.371 | | 0.713 |
| Q6h | The inclusion of more IT in learning and teaching botany (applications, games ... ) | 4.15 | 4 | 5 | 1.596 | | 0.851 |
| Q6f | More group work | 4.13 | 4 | 3 | 1.525 | | 0.612 |
| Q6i | Organize competitions in botany | 3.67 | 4 | 6 | 1.898 | | 0.705 |
| | Cronbach's alpha | | | | | 0.832 | 0.729 |
| | Eigenvalue | | | | | 3.18 | 2.36 |
| | % of variance | | | | | 35.4 | 26.3 |

## 4. Discussion

As far as we know, there aren't any comparable studies on views about plants and school teaching of botany from the perspective of biology teachers, as well as teachers of other subjects as in the first part of the study. The latter were the control group as a reflection of social pressures and normative beliefs which then influence perceived and actual behaviours [22,23].

The study provided several findings that can serve as a starting point for further, more detailed studies as well as a basis for evidence-based interventions. This assertion is supported by the values of Cronbach's alphas, which in most cases showed adequate values, and by PCA analyses, which showed principal components and component loadings that can be used to explain the maximum percentage of variance. In addition, CFA models at the latent variable level revealed the possible constructs to be explored. In analysing the answers, however, we could see patterns in some cases that fit what is already known as well as patterns that are confusing and raise more questions than answers. In the following text, we will try to comment on all the research questions.

Several conclusions can be drawn from the analysis of the responses to the first part of the study on teachers' opinions about plant knowledge and botany content in school, the differences between these two areas, and the two cohorts of teachers. The most important finding is that the concepts of "plant blindness" [7], "plant awareness" [5], and similar ones cannot be inferred from elementary and secondary school teachers' opinions about general plant knowledge because the means, medians, and modes in both groups (biology teachers and teachers of other subjects) were high. This result indicates that most teachers find knowledge about plants fascinating, interesting, important, attractive, and exciting, which are not descriptions for plant blindness. The differences between the two groups were not statistically significant; this is surprising since a difference in favour of biology teachers was expected. The results cannot be compared with the results of other studies because we could not find any. However, according to our results, we can say that the “extinction of plant education” [8] was not due to a lack of public interest in plants. On the other hand, if plant awareness is considered a synonym for a lack of interest in the university botany curriculum, the fears may be justified, but based on our results, we cannot say that teachers of all subjects were not interested in and/or unaware of plants in their daily routine. Without appropriate studies, we can only speculate about the applicability of our results to a broader public or university level. In our opinion, plants are generally ignored in the same way that other living things in the environment are overlooked [24–26].

While we can say that, on average, teachers have a high opinion of plant-related topics, the same cannot be said about school botany. In all aspects measured by a five-item scale (Table 3), there is a significant drop, sometimes by as much as two points, on a seven-point scale. School botany, while still considered important by the majority, is no longer considered exciting or attractive. It was interesting to note that the differences between biology teachers and teachers of other subjects were small in terms of effect sizes, and even here it was surprising that non-biology teachers considered the subject more attractive than their biology colleagues. Following the observations of Tranter [27] and Prokop et al. [28], we can simply conclude that plants and knowledge about them are positively valued but school botany is not. Even more so, it is the opposite of what it should be.

When asked about a part of biology that should be eliminated from the curriculum, differences emerged both between the two groups of teachers and between the biological disciplines within a group. In general, biology teachers are less likely to remove something from the curriculum; however, it appeared that some disciplines (e.g., human biology) were more strongly supported by biology teachers than physiology, zoology, and microbiology, and ecology was more strongly supported by others than the evolution of living beings, which was second even to botany (Table 6). We see that biology teachers would sacrifice human anatomy last and human evolution first, whereas teachers of other subjects would also sacrifice human anatomy last and microbiology first. It is interesting to note that there was no difference between teachers of all subjects with respect to evolution. Botany shares basically the same group as zoology and is in the middle of both groups. It can be concluded that botany is probably not the most popular subject, but there are many subjects that are less popular. Based on the responses, three factors were extracted. The first factor (explained variance = 24.9%; Cronbach’s alpha = 0.878) groups the variables human biology (Q3a), cell biology (Q3b), botany (Q3c), ecology (Q3e), and zoology (Q3k). All disciplines form the traditional core curriculum of biology, so we cannot say that botany differs in a good or bad way from the other disciplines. The second factor (explained variance = 21.8%; Cronbach’s alpha = 0.845) was formed by the variables physiology (Q3h), genetics (Q3i), and microbiology Q3j. All three disciplines were in the lower range of popularity. The final, third factor retained after parallel analysis was an evolution factor formed by Q3f and Q3g (explained variance = 20.5%; Cronbach’s alpha = 0.992). Knowledge about the attitudes and knowledge regarding evolution are among the most frequently studied topics in biology and belong to a group of controversial educational topics [29]. There is no better explanation for the low status of evolution among biology teachers than the fact that even some biology teachers have problems accepting it in the sense that “nothing in biology makes sense except in the light of evolution” [30]. The other explanation, i.e., that it is the most difficult subject that crosses the boundaries between disciplines, is another plausible explanation, but teachers of other subjects (where evolution is not a part of the programme) share the same low attitude towards evolution. The issues raised need to be explored in more detail in follow-up studies. Based on the results, we cannot say that botany is in any way endangered. However, if interest in it is to be stimulated, one of the likely solutions might be to connect botanical topics more closely with more popular biological disciplines, e.g., ecology and human biology.

Following the idea that teachers are, at least theoretically, the most important determinant of school quality, we focused our research on them as they can shape and influence classes and, through the methods they use, affect students' knowledge, skills, and attitudes toward botany. Since botany is composed of several sub-disciplines, we asked biology teachers about their interest in these subjects. From the results presented in Table 7, we can conclude that at the top of biology teachers' interests are plant ecology and horticulture, and they form a principal component with geobotany. At the bottom are plant morphology, plant anatomy, and systematics (taxonomy); these can be considered to form the traditional core botanical curriculum. The results can be used not as much to change topics about plants but to link them into operational units. For example, horticulture, where teachers can express their interests and knowledge and which is not part of the official curriculum, can serve as a vehicle to teach students systematics and plant anatomy in an ecological context. Through some speculation, we can extend the results to university level, where horticulture is mostly not part of the curriculum in biology departments. This may be reflected in a top-down manner in pre-university levels of education.

Looking for an answer to the question of how to make botany more interesting, we obtain responses that point to active teaching methods, linking school biology to everyday contexts, and the like. Interestingly, there was less preference for methods that promote digitization of botany or support competitions. We can only (dis)agree with teachers and relate their views to findings in the literature [31–33]. However, from the results of our study, we cannot infer why they do not use active methods in their teaching, as their use falls within the realm of teacher autonomy and professionalism. We can only conclude that our findings are not the end, but rather a beginning that requires a next step in research, as several authors have already suggested [10–12]. Perhaps, one of the solutions to the problems of plant awareness [6] and synonymous terms [10] will be to stop lamenting about it and start thinking about life consciousness directed towards all living beings in terms of the ecocentric ethic [12,34].

Finally, we have to say that the study and conclusions drawn from data can be biased in several ways. The first and the most severe bias can be a result of the respondents' self-selection, because the call for participation was general and addressed to all teachers. No benefits or consequences were foreseen to those who answered or those who did not. For this reason, we can only speculate that they had the same experiences and opinions and acted in accordance with those who did not respond or to different populations. However, it is impossible to compensate for this possible weakness in the study design. The second bias may be instrument bias, whereby some of the factors that may also be important are not included in the study. However, even if it may be of interest, we have not collected on purpose all the data that could be identified as personal or lead to the violation of the anonymity of the respondents. The third bias could be the content validity of the model and the constructs included. However, we have tried to avoid these by adjusting the instruments tested and carefully reviewing the constructs.

## 5. Conclusions

Regarding the first three objectives of the study, we can see that among the teachers who participated in this initial study, regardless of the profile of the subject they teach (both biology and other subjects), similar attitudes prevail towards botany in everyday life and in the classroom. All had a high opinion of the importance of plants and botany for life and education but not of school botany. Therefore, botany is still in the middle of all teachers' opinions, which is a response to objective four. Objectives five and six were met by analysing biology teachers' attitudes and interests and suggesting ways to make botany more attractive as a subject. Still, within botany, teachers were most interested in ecology and horticulture. They suggested that botany would be more interesting with active teaching methods and references to everyday contexts. However, it remains unclear why this is so, as the level of autonomy they are given allows them to introduce such changes. Another outcome of our research was the validation of the instruments (scales) used in the study, which can be used in further research.

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**Data Availability Statement:** Supporting data and results not included in the paper can be obtained upon request from B.M. and A.Š. After the completion and publication of Nataša Klet's doctoral thesis (at the end of 2023), the above data will be available via the Zenodo platform.

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## References

1. Hattie, J.A.C. Teachers make a difference: What is the research evidence? In Proceedings of the Building Teacher Quality: What Does the Research Tell Us ACER Research Conference, Melbourne, Australia, 19–21 October 2003; Available online: https://research.acer.edu.au/cgi/viewcontent.cgi?article=1003&context=research_conference_2003 (accessed on 15 January 2023).
2. Mourshed, M.; Barber, M. *How the World's Best-Performing School Systems Come Out on Top*; McKinsey and Company: London, UK, 2007.
3. Bozniak, E.C. Challenges facing plant biology teaching programs. *Plant Sci. Lett.* **1994**, *40*, 42–46. [CrossRef]
4. Hershey, D.R. Plant neglect in biology education. *BioScience* **1993**, *43*, 418. [CrossRef]
5. Pany, P.; Meier, F.D.; Dünser, B.; Yanagida, T.; Kiehn, M.; Möller, A. Measuring Students' Plant Awareness: A Prerequisite for Effective Botany Education. *J. Biol. Educ.* **2022**. [CrossRef]
6. Parsley, K.M. Plant awareness disparity: A case for renaming plant blindness. *Plants People Planet* **2020**, *2*, 598–601. [CrossRef]
7. Wandersee, J.H.; Schussler, E.E. Preventing plant blindness. *Am. Biol. Teach.* **1999**, *61*, 82–86. [CrossRef]
8. Stroud, S.; Fennell, M.; Mitchley, J.; Lydon, S.; Peacock, J.; Bacon, K.L. The botanical education extinction and the fall of plant awareness. *Ecol. Evol.* **2022**, *12*, e9019. [CrossRef] [PubMed]
9. Jose, S.B.; Wu, C.-H.; Kamoun, S. Overcoming plant blindness in science, education, and society. *Plants People Planet* **2019**, *1*, 169–172. [CrossRef]
10. Amprazis, A.; Papadopoulou, P. Plant blindness: A faddish research interest or a substantive impediment to achieve sustainable development goals? *Environ. Educ. Res.* **2020**, *26*, 1065–1087. [CrossRef]
11. Thomas, H.; Ougham, H.; Sanders, D. Plant blindness and sustainability. *Int. J. Sustain. High. Educ.* **2022**, *23*, 41–57. [CrossRef]
12. Knapp, S. Are humans really blind to plants? *Plants People Planet* **2019**, *1*, 164–168. [CrossRef]
13. Kissi, L.; Dreesmann, D. Plant visibility through mobile learning? Implementation and evaluation of an interactive Flower Hunt in a botanic garden. *J. Biol. Educ.* **2018**, *52*, 344–363. [CrossRef]
14. Nyberg, E.; Sanders, D. Drawing attention to the 'green side of life'. *J. Biol. Educ.* **2014**, *48*, 142–153. [CrossRef]
15. Strgar, J. Increasing the interest of students in plants. *J. Biol. Educ.* **2007**, *42*, 19–23. [CrossRef]

16. Šorgo, A.; Dojer, B.; Golob, N.; Repnik, R.; Repolusk, S.; Pesek, I.; Ploj Virtič, M.; Špernjak, A.; Špur, N. Opinions about STEM content and classroom experiences as predictors of upper secondary school students' career aspirations to become researchers or teachers. *J. Res. Sci. Teach.* **2018**, *55*, 1448–1468. [CrossRef]
17. Šorgo, A.; Špernjak, A. Professor should be topless or change something in biology class. *Vzgoja Izobr.* **2007**, *38*, 37–40. (In Slovenian)
18. The jamovi Project. jamovi (Version 2.3) [Computer Software]. 2022. Available online: https://www.jamovi.org (accessed on 10 February 2023).
19. Byrne, B.M. *Structural Equation Modelling with AMOS: Basic Concepts, Applications, and Programming*, 3rd ed.; Routledge: New York, NY, USA, 2016.
20. Field, A. *Discovering Statistics Using IBM SPSS Statistics: And Sex and Drugs and Rock "N" Roll*, 4th ed.; Sage: London, UK, 2013.
21. Kline, R.B. Promise and pitfalls of structural equation modeling in gifted research. In *Methodologies for Conducting Research on Giftedness*; Thompson, B., Subotnik, R.F., Eds.; American Psychological Association: Washington DC, USA, 2010; pp. 147–169.
22. Conroy, D.E. Progress in the development of a multidimensional measure of fear of failure: The Performance Failure Appraisal Inventory (PFAI). *Anxiety Stress Coping* **2001**, *14*, 431–452. [CrossRef]
23. Erten, S.; Bamberg, S.; Graf, D.; Klee, R. Determinants for Practicing Educational Methods in Environmental Education—A Comparison between Turkish and German Teachers Using the Theory of Planned Behavior. In Proceedings of the III Conference of European Researchers in Didactic of Biology, Santiago de Compostela, Spain, 27 September–1 October 2000; García-Rodeja Gayoso, I., Ed.; Universidade de Santiago de Compostela: Santiago de Compostela, Spain, 2001; pp. 375–389.
24. Gerl, T.; Randler, C.; Jana Neuhaus, B. Vertebrate species knowledge: An important skill is threatened by extinction. *Int. J. Sci. Educ.* **2021**, *43*, 928–948. [CrossRef]
25. Hooykaas, M.J.; Schilthuizen, M.; Aten, C.; Hemelaar, E.M.; Albers, C.J.; Smeets, I. Identification skills in biodiversity professionals and laypeople: A gap in species literacy. *Biol. Conserv.* **2019**, *238*, 108202. [CrossRef]
26. Robles-Moral, F.J.; Fernández-Díaz, M.; Ayuso-Fernández, G.E. What Do Pre-Service Preschool Teachers Know about Biodiversity at the Level of Organisms? Preliminary Analysis of Their Ability to Identify Vertebrate Animals. *Sustainability* **2022**, *14*, 11406. [CrossRef]
27. Tranter, J. Biology: Dull, lifeless and boring? *J. Biol. Educ.* **2004**, *38*, 104–105. [CrossRef]
28. Prokop, P.; Prokop, M.; Tunnicliffe, S.D. Is biology boring? Student attitudes toward biology. *J. Biol. Educ.* **2007**, *42*, 36–39. [CrossRef]
29. Torkar, G.; Šorgo, A. Evolutionary content knowledge, religiosity and educational background of Slovene preschool and primary school pre-service teachers. *EURASIA J. Math. Sci. Tech. Ed.* **2020**, *16*, em1855. [CrossRef] [PubMed]
30. Dobzhansky, T. Nothing in biology makes sense except in the light of evolution. *Am. Biol. Teach.* **1973**, *75*, 87–91. [CrossRef]
31. Balding, M.; Williams, K.J. Plant blindness and the implications for plant conservation. *Conserv. Biol.* **2016**, *30*, 1192–1199. [CrossRef] [PubMed]
32. Echeverria, A.; Ariz, I.; Moreno, J.; Peralta, J.; Gonzalez, E.M. Learning plant biodiversity in nature: The use of the citizen–science platform iNaturalist as a collaborative tool in secondary education. *Sustainability* **2021**, *13*, 735. [CrossRef]
33. Michael, J. Where's the evidence that active learning works? *Adv. Physiol. Educ.* **2006**, *30*, 159–167. [CrossRef] [PubMed]
34. Kortenkamp, K.V.; Moore, C.F. Ecocentrism and anthropocentrism: Moral reasoning about ecological commons dilemmas. *J. Environ. Psychol.* **2001**, *21*, 261–272. [CrossRef]