education sciences

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The Effect of Block Class Scheduling on the Achievements of Primary School Students in Nature and Biology Classes

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Abstract: The objective of this study was to investigate whether the class scheduling of Nature and Biology classes in blocks results in better learning success for primary school students, and whether this depends on the average student success rate (i.e., student performance categories), age, or prior knowledge. For this study, we have assumed that block scheduling results in better success rates for older lower-performing primary-school students. The research included 773 fifth- to eighth-grade students from 14 Croatian primary schools. The students fell into two groups: one group attending 45-min Nature and Biology lessons twice a week (single-scheduled classes), and another group attending a 90-min lesson once a week (block-scheduled class). To assess the level of student learning success, all students underwent both an initial and final written exam in Nature and/or Biology, specific to each grade. The rmANOVA proved that there was a significant interaction among class scheduling, performance categories, and the initial and final written exam scores of fifth- and seventh-grade students. Such a correlation was not found among the sixth- and eighth-grade students. Our findings further indicate that students achieve better results in block-scheduled classes at the end of primary school education, and that block class scheduling does not necessarily result in improved student achievement, particularly in lower-performing students.

Keywords: weekly schedule; student age; conceptual associations; students' achievement; science education

Citation: Labak, I.; Sertić Perić, M.; Radanović, I. The Effect of Block Class Scheduling on the Achievements of Primary School Students in Nature and Biology Classes. *Educ. Sci.* **2021**, *11*, 550. https://doi.org/10.3390/educsci11090550

Academic Editor: Alessandro Bertoni

Received: 21 August 2021
Accepted: 13 September 2021
Published: 16 September 2021

1. Introduction

Successful and effective teaching and learning depend on the detailed student-centered planning (micro-planning) of teaching [1,2]. This includes choosing effective teaching methods and learning activities for achieving good learning outcomes, as well as adapting evaluation approaches to assess those outcomes. Planning of teaching also includes the choice of class scheduling, i.e., block-scheduled classes (two consecutive teaching classes, lasting a total of 90 min) or single-scheduled classes (two teaching classes per week, each lasting 45 min). Because of its length, the block-scheduled class allows for a wider range of teaching strategies and methods that require active and independent student engagement, such as collaborative, exploratory and/or research-based learning [3–6]. These active learning approaches are strongly represented in STEM subjects that include the observation of natural phenomena and processes, and the application of practical work, experiments and/or demonstrations, which are often difficult to implement within a single class. Thus, Science, Nature and Biology teachers often tend to organize block-scheduled classes, following the recommendations for effective teaching in the field of natural sciences [7–9].

Previous research on the effects of block class scheduling on student achievements yielded opposite conclusions. While some studies indicate higher learning success by students attending block-scheduled classes than students from single-scheduled classes [10–12],

other research has suggested that students perform better after being taught in single-scheduled classes [13–15]. Therefore, many authors conclude that it is difficult to determine the effect of block-scheduled classes on students' achievement [13,16,17]. However, most of the previous studies have reviewed the effects of block-scheduled classes on the students' success at the high-school level [18–20]. Our previous study on the effects of block-scheduled Biology classes was also conducted at the secondary education level and showed that block-scheduled teaching does not affect all students equally [8]. The study concluded that in planning and introducing a block schedule in Biology classes, one should take into account not only the students' age, previous knowledge and average success (i.e., student performance category) but also the complexity of educational topics [8]. The results further indicated that block-scheduled Biology teaching generally does not have a significant effect on the success of good and excellent high-school students, because they are successful regardless of the scheduling, whereas it could impair the success of low-performing high-school students.

However, few studies have considered the effects of block class scheduling at the primary (i.e., elementary) school level (but see [21]), especially among adolescent students in the fifth to eighth grades. These students undergo a critical developmental and transitional phase, responding to their physical changes, and social, self-confidence and cognitive challenges [22,23], often exhibiting a decline in student achievement [21,24]. Therefore, it is needed to investigate the effect of block scheduling at the (upper) primary school level, taking into account the prior findings on the effects of student age, performance categories and prior knowledge on exam success [8].

Prior knowledge is one of the strongest cognitive predictors of academic achievement [25,26]. It is necessary for effective learning at higher cognitive levels, developing conceptual understanding and problem-solving abilities [27] as well as for building a complex knowledge network and reaching better academic achievement throughout all education levels [28,29]. In order to expand our previous knowledge, in this paper, we posed the following research questions: (i) whether the block scheduling of Nature and Biology classes results in increased student success in these subjects among primary school students, and (ii) whether the learning success significantly varies, depending on students' performance categories and prior knowledge. The aim of this study, which builds on these two research questions, is to provide clear empirical evidence that would enhance our understanding of the effects of block scheduling on students' achievement, depending on the students' age, average performance, and prior knowledge. We hypothesized that, in comparison with single-scheduled Nature and Biology classes, block scheduling results in better success for older primary school students demonstrating a lower-than-average performance. Our findings could provide valuable data that are relevant for curriculum developers and pedagogical practitioners who face challenging decisions on the most efficient class-scheduling formats for teachers and students of various interests and overall performance. In addition, the present study could provide implications for government bodies that are challenged by organizing effective teaching in an epidemiologically adapted environment such as that found during the COVID-19 pandemic, when it was recognized that block scheduling could reduce the number of transitions in a school day and restrict social interactions among different students and teachers (e.g., [30,31]).

2. Materials and Methods

2.1. Study Sample and Design

In this study, learning success and overall students' performance were assessed based on the results of the two consecutive written exams (initial and final) in Nature (5th and 6th grades of primary school) and Biology (7th and 8th grades of primary school) classes. The study included 773 students from 14 Croatian primary schools, aged 11 to 14 (5th to 8th grades). Prior to the children's participation in the research, their parents signed written consent, and the research was permitted by the principals of the participating schools. The

structure of the student sample, teaching topics, and teaching activities applied in each grade are presented in Table 1.

Table 1. Overview of the student structure, educational topics, learning outcomes, and the respective teaching activities within the present study. N—sample size (number of students included in the study within each grade).

Grade	Student Age	Educational Topics	Learning Outcomes (Students Are Able to . . .)	N (Students)	Teaching Activities
5th	11	Cells, unicellular and multicellular organisms	- Recognize and draw the subcellular components characteristic of animal and plant cells; - Explain the differences between unicellular and multicellular organisms; - Explain the importance of cell division to the organisms.	189	Practical work (microscopic observation of living cells and macroscopic observation of cell models), observation and demonstration with drawing and discussion.
6th	12	Continental deciduous forests	- Describe the basic features of continental deciduous forests; - Distinguish the forest layers; - Identify plants, fungi and animals growing and living in continental deciduous forests; - Able to explain the functional importance of forests to people.	163	Macroscopic observation of the variability of forest living organisms, drawing and oral presentation with discussion.
7th	13	Algae and fungi	- Differentiate between the morphological and functional characteristics of unicellular and multicellular algae; - Identify the phylogeny of algae based on plastid morphology and recognize the related species; - Explain why fungi are separate from plants, animals, protists and bacteria; - Differentiate between parasitic and saprophytic fungi; - Explain what lichens are; - Discuss the importance of fungi in human life.	183	Practical work (microscopic and macroscopic observation of living algae and fungi, comparison of unicellular and multicellular algae, hyphae, and lichens by structure), drawing and oral presentation with discussion.
8th	14	Structure and function of sex organs	- Link the structure and function of sex organs; - Explain the functional significance of the menstrual cycle; - Explain the appropriateness and purpose of different contraception methods; - Explain the meaning and importance of responsible sexual behavior.	238	Themed essays and watching an educational video on the structure and functions of sex organs, followed by content systematization and student conversation and discussion based on observing the educational video content.

The students (i.e., classes) were divided into two groups, differing in the session lengths of Nature and Biology class scheduling (i.e., scheduling type) before and during the study:

1. Classes with the traditional 45-min lesson in Nature and Biology, held twice a week (group S—abbreviated from single-schedule: sample of 402 students);

2. Classes with a block-scheduled lesson (90 min) in Nature and Biology, held once a week (group B—abbreviated from block-schedule: sample of 371 students).

The two groups of students (S and B) had a similar thematic schedule (educational topic) in Nature and Biology within each grade (Table 1).

The study consisted of three phases. In the first phase, all students took the same initial written assessment exam that was specific to each grade. The initial written exam consisted of 20 questions. These questions enabled us to assess the initial levels of student knowledge, i.e., the learning outcomes related to a particular teaching topic (Table 1), achieved prior to the research. The second phase included teaching within the traditional 45-min Nature and Biology class twice a week (the S group) or within the block-scheduled (90-min) Nature and Biology class once a week (the B group). To ensure the uniformity of the teaching style, each teacher was given a ready-to-use uniform lesson plan for each educational topic that included elaboration of the associated learning outcomes and concepts (Table 1). This contributed to ensuring that teaching methods did not influence the learning within differently scheduled classes.

For students in group S, two single-scheduled Nature and Biology lessons were held twice a week. During the first lesson, one topic was taught and, after two days, the second lesson was taught, covering a conceptually related topic. At the beginning of the conceptually related topic (i.e., a new teaching unit), the students revised the content taught in the previous lesson. In group B, based on the block-scheduled classes, both conceptually related topics were taught on the same day, during the 90-min lesson. Although the same teaching activities were applied in both groups (S and B) with the aim of achieving the same learning outcomes, the implementation of teaching differed in terms of temporally "merging" or "separating" conceptually related topics. For example, in the 5th-grade class, students from group B were simultaneously taught about the differences between prokaryotic and eukaryotic cells, while students in group S were taught about the two cell types in two separate 45-min lessons. Table 1 shows the topics covered in the other lessons.

In the third phase, students took the second (final) written exam that was specific to each grade. The second exam consisted of 20 questions, which were different from the questions in the initial assessment but that examined the same learning outcomes within individual grades (Table 1). The teaching topics and learning outcomes for this research were selected according to the curricula presented in the Croatian National Education Standard (CNES) for primary education [32].

2.2. Statistical Analysis

We used an rmANOVA (repeated measures analysis of variance) to test for significant differences in student success between the initial and final written exams, among students of different performance categories and scheduling types (B vs. S) within specific grades (5th to 8th). If the rmANOVA indicated the existence of statistically significant differences, a Tukey HSD post hoc test was additionally conducted, which indicated specific differences among individual groups of students. We tested the following:

- Generally, whether there are significant differences in student achievement (percentage score) at the initial and final written exams between groups B and S, and whether there is a significant correlation between student achievement and class scheduling (B vs. S);
- Specifically, whether there are significant differences in student achievement (percentage score) at the initial and final written exams between different student performance categories, within groups B and S, and whether there is a significant correlation between the achievement levels of students from different performance categories and class scheduling (B vs. S).

The student performance categories were defined, based on the average percentage score of the initial and final written exam conducted during this study instead of the overall student achievement (i.e., average grade across all subjects). This was due to potentially inconsistent evaluation criteria in individual subjects, as well as docimological anomalies,

depending on the teacher [33]. Four student performance categories were defined: low (average percentage score of the initial and final written exam in Nature and Biology < 40%), medium (40–69%), good (70–89%), and excellent (90–100%). A 40% limit was taken because the usual mean score of written exams in Biology in the Republic of Croatia is 40% [34]. In addition, we grouped students into the following groups, according to scheduling type and performance categories: "B*low", "B*medium", "B*good", "B*excellent", "S*low", "S*medium", "S*good", and "S*excellent". Prior to performing the statistical analysis, the source data (percentage scores of the initial and final written exams, average percentage score of the initial and final written exam) were log-transformed (log(x + 1)) to realize a more normal data distribution and stabilize the variance. In all analyses, statistical significance was determined at the level of $p < 0.05$. All data analyses were performed using the statistical package Statistica 13.3. (TIPCO Software Inc., Palo Alto, CA, USA). For determining the internal consistency of the written exams, the Cronbach's reliability coefficient (α) was determined for both exams within each class. The Cronbach's α coefficients were calculated using the SPSS 22 software package (IBM Corp., Armonk, NY, USA), thanks to the Center for Educational Research and Development (CERD) of the Institute for Social Research in Zagreb (ISRZ). The α-values, as reliable descriptors of learning achievement, ranged between $\alpha = 0.592$ (5th grade, for the initial written exam) and $\alpha = 0.712$ (6th grade, for the final written exam).

3. Results

The results of the statistical analyses indicate that in all grades (5th to 8th), student achievement (i.e., percentage score) in Nature and Biology written exams significantly depends on the student performance categories, while the scheduling type (B vs. S) does not affect student achievement equally in all grades (Table 2).

Table 2. Among-grade differences in the initial and final written exam scores (i.e., exam percentage) between students attending different scheduling types (block, B, vs. single, S), and among students representing different scheduling performance categories (B*low vs. B*medium, vs. B*good, vs. B*excellent, vs. S*low, vs. S*medium, vs. S*good, vs. S*excellent). The table also presents significant interactive effects among the average students' performance (i.e., a mean score of the two consecutive exams—initial and final written exams—that served as a base for defining student performance categories), scheduling type, and performance categories' scheduling types across individual grades.

	Scheduling Type			**Scheduling × Performance Categories**		
Grade	Mean score of the initial and final written exams	Initial vs. final written exam score	Interaction: mean score of the initial and final written exams and scheduling type	Mean score of the initial and final written exams	Initial vs. final written exam score	Interaction: Mean score of the initial and final written exams and scheduling × performance categories
5th	n.s.	***	*	***	***	***
6th	***	***	n.s.	***	***	n.s.
7th	***	n.s.	***	***	*	***
8th	**	***	n.s.	***	**	n.s.

Asterisks indicate significant differences in the means of the written exam scores between the different student groups, based on an rmANOVA: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, n.s.—not significant. Detailed descriptions of the different student groups are given in the Methodology.

In the fifth grade, a statistically significant interaction was found between the average students' performance (mean scores of the initial and final written exams) and scheduling type ($F_{(1, 187)} = 4.22$, $p = 0.041$), and the mean score of the two consecutive written exams and scheduling ∗ performance categories ($F_{(6, 182)} = 4.13$, $p < 0.001$). However, statistically significant differences in the scores of written exams between groups B and S were not found ($p = 0.393$; Table 2, Figure 1a). Fifth-graders generally scored significantly better in the final than in the initial exam (Table 2, Figure 1a). In addition, significant differences between the initial and final written exam scores among students of different performance categories were found (Table 2, Figure 1b). For example, the "S*good" and "S*excellent"

categories made significant progress in the final written exam, compared to the initial assessment. However, the "B*low" student category did not make progress compared to the initial assessment (Figure 1b). It seems that the observed improvement between the initial and final exams in the fifth grade depends rather on the average student performance in solving the written exam, or on students' motivations and their ability to learn, than on the scheduling type (Table 1).

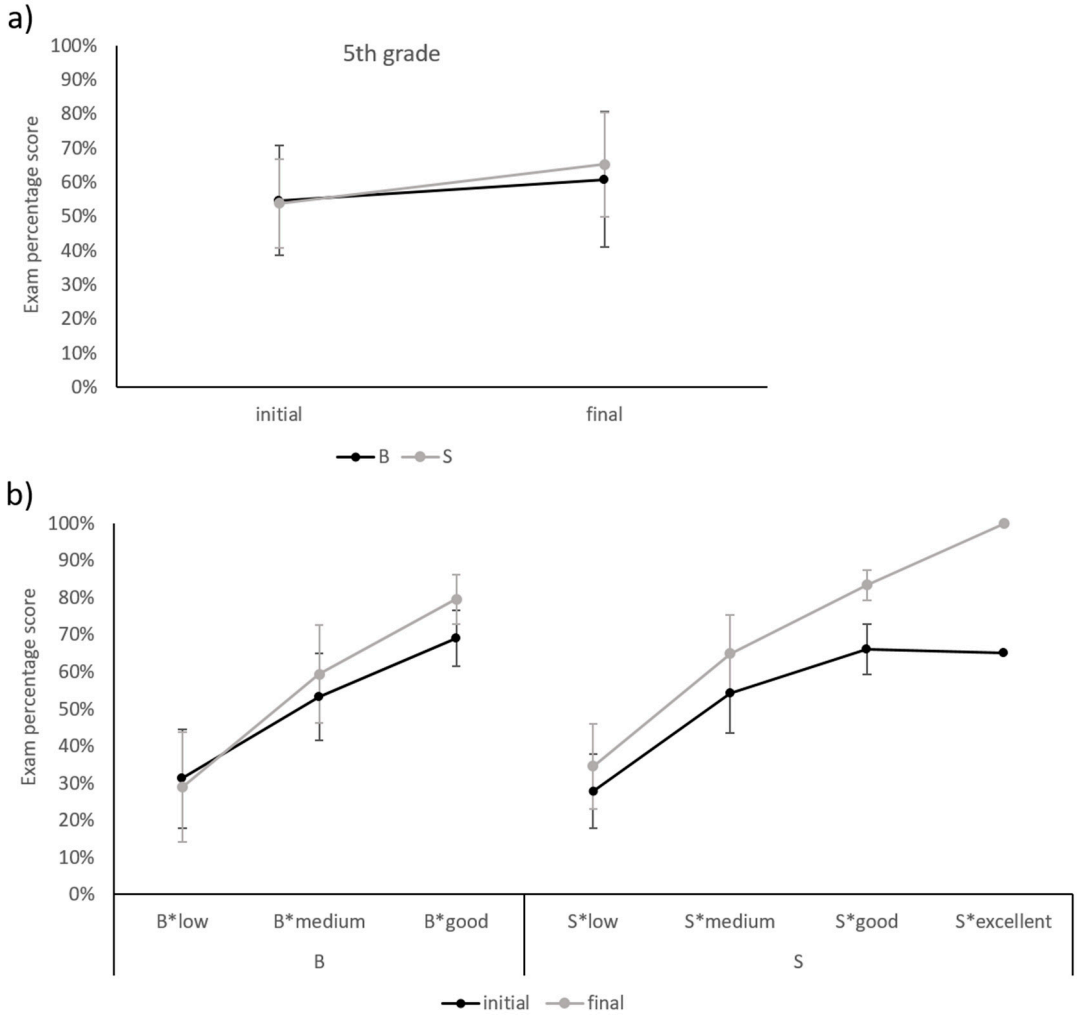

Figure 1. Mean (±SD) initial and final written-exam percentage scores among the fifth-grade students: (**a**) after teaching in block- vs. single-schedule Nature and Biology classes; (**b**) for different class scheduling and student performance categories.

In the sixth grade, there was no statistically significant interaction between the mean scores of the initial and final written exams and the scheduling type ($F_{(1, 161)} = 2.73$, $p = 0.101$) or between the mean scores of the initial and final written exams and student performance categories ($F_{(5, 157)} = 2.01$, $p = 0.080$) (Table 2, Figure 2). Sixth-graders generally scored significantly better in the final than in the initial written exam, and students who were taught in single-scheduled classes scored significantly better on both tests than students taught in block classes (Table 2, Figure 2a). In addition, significant differences in student achievement (i.e., the percentage score of the initial and final written exams) between different performance categories (good > medium > low) were found (Table 2, Figure 2b). Most students achieved significantly better results in the final exam, and only students from the "S*low" category were slightly more successful in the initial exam (Figure 2b).

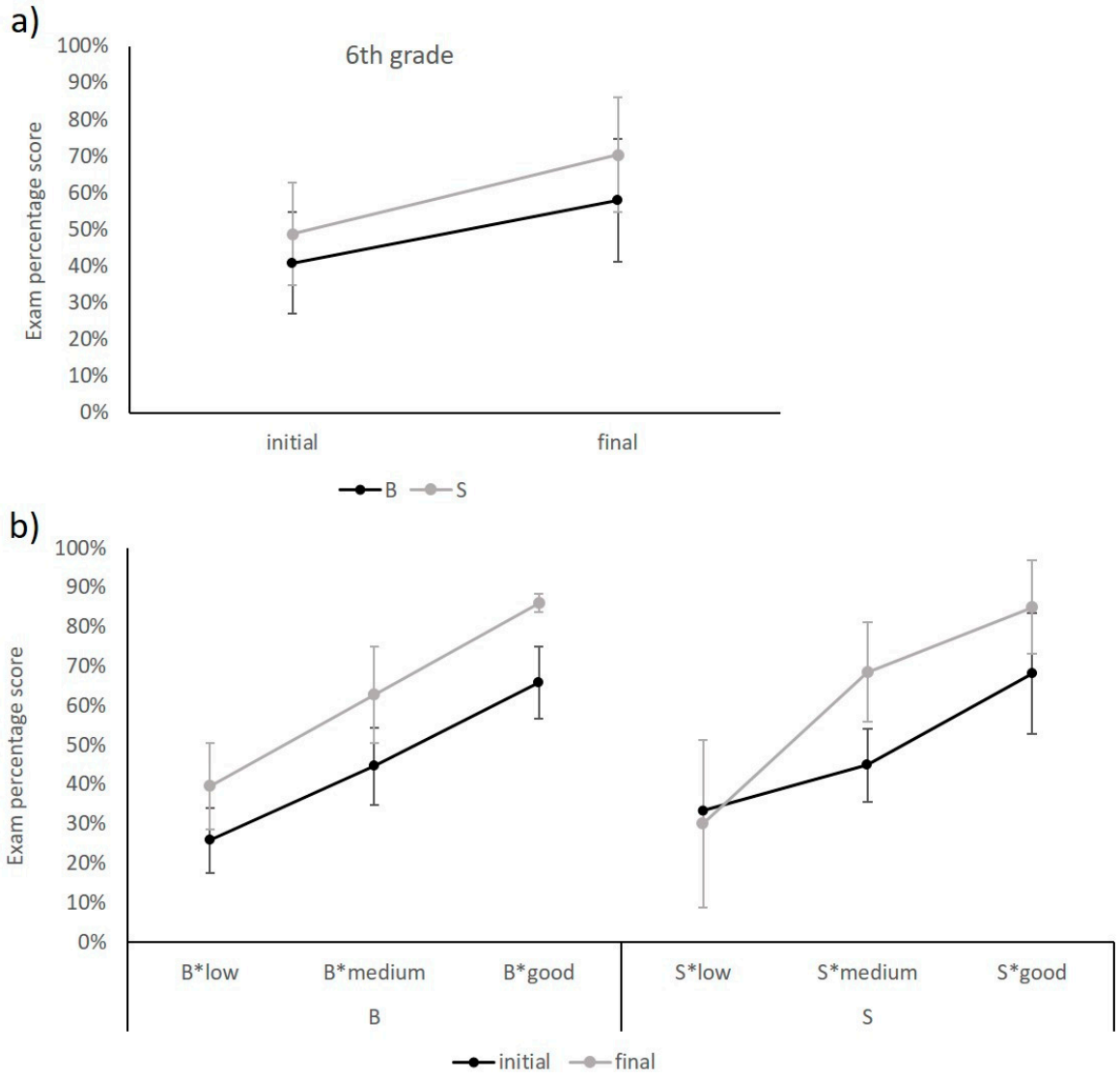

Figure 2. Mean (± SD) initial and final written-exam percentage scores among the sixth-grade students: (**a**) after teaching in block- vs. single-schedule Nature and Biology classes; (**b**) for different class scheduling and student performance categories.

In the seventh grade, a statistically significant interaction was observed between the mean scores of the initial and final written exams and the scheduling type ($F_{(1, 181)} = 16.02$, $p < 0.001$), as well as between the mean scores of the initial and final written exams and student performance categories ($F_{(5, 177)} = 4.87$, $p < 0.001$) (Table 2, Figure 3). Seventh-graders who were taught in block-scheduled classes generally performed significantly better than those students taught in single-scheduled classes. However, no significant differences were found between their success in the initial and final written exams (Table 2, Figure 3a). It was observed that in the final exam, compared to the initial assessment, students from group S generally achieved slightly better results, while students from group B demonstrated lower scores. In the seventh grade, we found significant ($p = 0.041$) differences in the score between the initial and final written exam among students of different performance categories (good > medium > low) (Figure 3b).

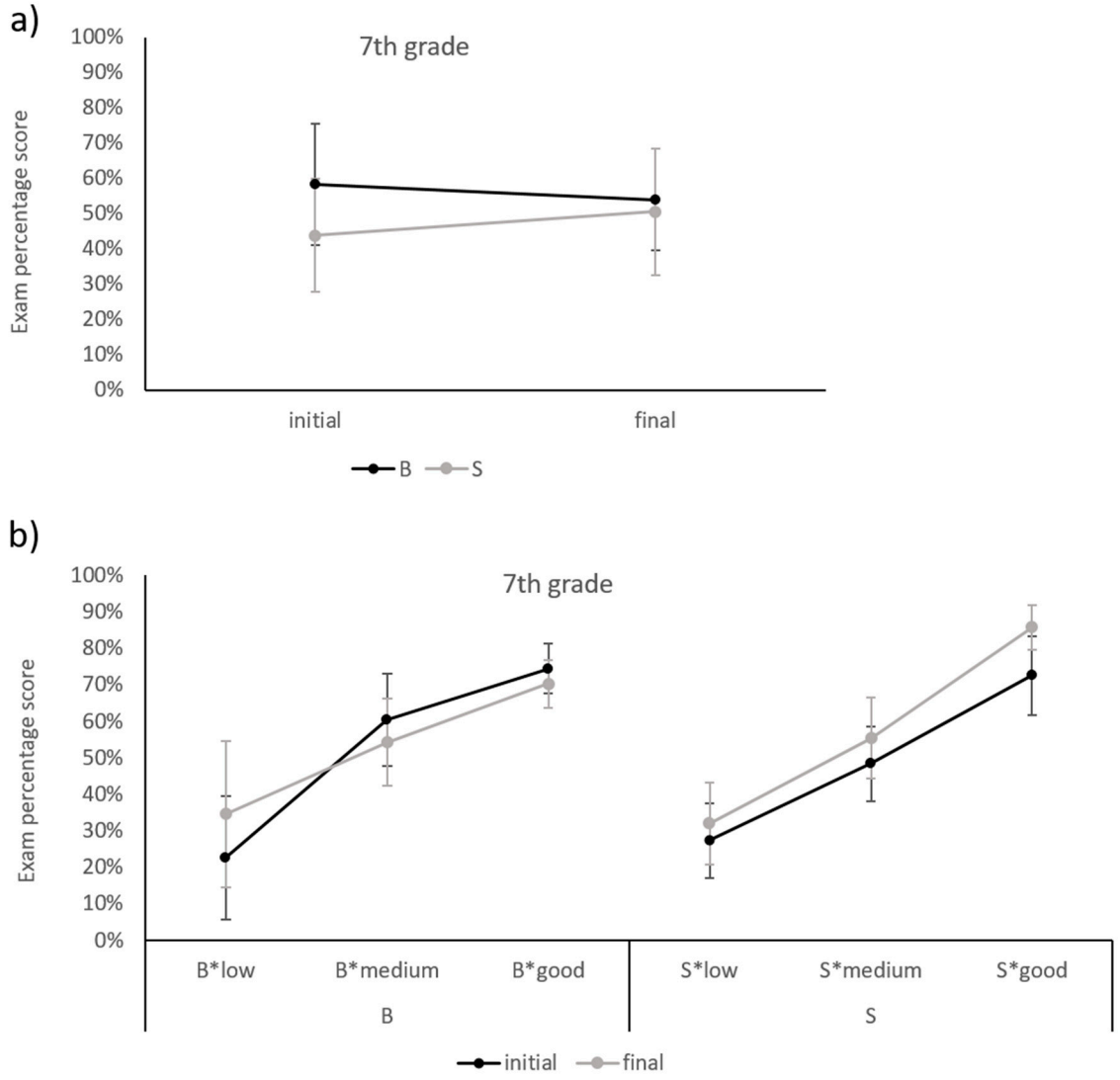

Figure 3. Mean (±SD) initial and final written exam percentage scores among the seventh-grade students: (**a**) after teaching in block- vs. single-schedule Nature and Biology classes; (**b**) for different class scheduling and student performance categories.

In general, in the eighth grade, students who were taught in block-scheduled classes performed significantly better than students who were taught in single-scheduled classes, and the results of the final exam were significantly better than in the initial assessment (Table 2, Figure 4). Only those students from the "B*excellent" category demonstrated slightly lower performance on the final exam in comparison to the initial assessment (Figure 4b). Significant differences in the mean scores of the initial and final written exams between students of different performance categories were proven (excellent > good > medium > low). However, there was no statistically significant interaction between the mean score of the initial and final written exams and the scheduling type ($F_{(1, 117)} = 0.94$, $p = 0.335$), nor between the mean score of the initial and final written exams and student performance categories ($F_{(6, 112)} = 0.95$, $p = 0.459$) (Table 2, Figure 4).

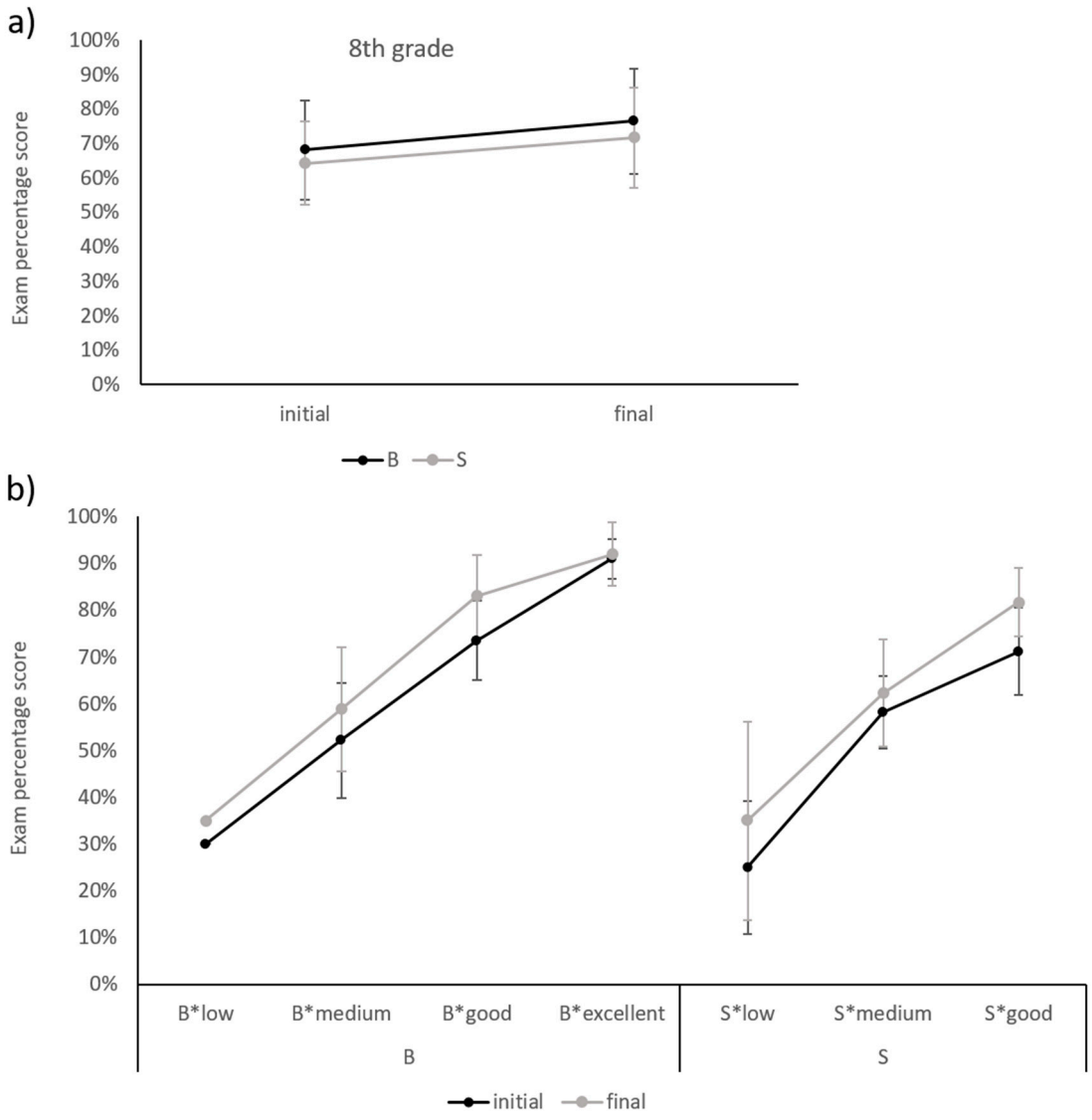

Figure 4. Mean (±SD) initial and final written exam percentage scores among the eighth-grade students: (**a**) after teaching in block- vs. single-schedule Nature and Biology classes; (**b**) for different class scheduling and student performance categories.

4. Discussion

Although block class scheduling has been introduced with the aims of better time management and improving student learning achievement [4,35,36], a clear positive effect of the scheduling type on student learning success has not been proven [14,37,38]. Gruber and Onwuegbuzie [13] examined the effect of block class scheduling on subject-dependent student success and did not find a positive effect on the levels of student achievement in science subjects (or in Mathematics or languages). On the other hand, Dickson et al. [19], based on their meta-analysis of 14 studies, concluded that block class scheduling in science subjects generally results in better achievements for students, while it could have a negative effect when teaching languages and Mathematics. Impelled by previous conflicting conclusions regarding the science subjects and our understanding that prior knowledge has a significant effect on student achievement [25], we assumed that the learning success of students who studied Nature and Biology in block-scheduled classes would depend on their prior knowledge and average achievement (i.e., student performance categories). In the present study, a significant interdependence of class scheduling and average student performance and student success (written-exam percentage scores) was found among fifth-grade students, who are transitioning from class- to subject-based teaching, at which

point Nature is one of the newly introduced subjects. The same pattern was also observed in seventh-graders, where Biology is a newly introduced subject. Such an interdependence was not observed among sixth- and eighth-grade students. The results of the present study also show that block-scheduled classes result in better student achievement only at the end of primary school (7th and 8th grade). A similar situation was observed in high-school students, where students at the beginning of high school (1st and 2nd grade) achieved better written-exam results in single-scheduled classes, whereas 3rd-grade students achieved better results when they were taught in block classes. Among fourth-graders, who are completing high school, equal levels of success were observed on the written exam, regardless of the teaching method [8].

The results of this study should also be discussed in the context of the interdependence of age-specific prior knowledge, (pre) knowledge of a particular biological concept, student performance categories, and applied teaching methods. Such interdependence is also recognized by Thomas [39], who emphasized that these three aspects (concepts/topics taught, the teaching method, and the appropriate level of cognitive development) together lead to successful learning in block-class scheduling.

The results observed among fifth- and sixth-grade students indicate that single-class scheduling is more effective, which corroborates the observations of some authors who have concluded that students perform better if they are taught in single-scheduled classes than in block classes [13–15]. However, the efficiency of scheduling (B vs. S) can largely depend on the concepts and topics taught, teaching activities, and the amount of time that teachers allocate for each teaching activity and teaching strategy [19,40]. For example, fifth-graders are transitioning from class-based to subject-based teaching, and to the adoption of new and more complex concepts, so it is likely that they need a period of adjustment to the new topics (concepts) and learning environment [41,42]. It is possible that, therefore, they showed better success rates when taught within single-scheduled classes, to which they were accustomed during class-based teaching. The advantage of block class scheduling is that it enables introducing several related topics at the same time. However, some teaching topics are better taught in smaller fragments, i.e., in a single lesson [43,44]. Topics related to an organism structure (from the cell to the organism) are difficult for younger or lower-performing students [45], so students often develop misconceptions about them, i.e., wrong or (scientifically) inaccurate ideas that often prevent the formation and/or adoption of the correct concept [46,47]. The adoption of misconceptions is often encountered when teaching ecology-related content [46,48], which was the topic taught to sixth-graders during the present study, and which included a large number of new taxonomic and ecological terms. It is possible that the adoption of such concepts led to the lower exam scores of the sixth-grade students taught in block-scheduled classes, as they lacked the revision of the content taught in the previous lesson. The stepwise revision of the learned content is usual practice in single-class scheduling; it enhances the guided construction of concepts, which is very important for memory formation [49,50]. Furthermore, if block-scheduled classes are organized in the same (but time-prolonged) way as in traditional teaching, this may cause the opposite effect and result in lower student performance (as observed for lower-performing students in the present study). This was pointed out by Shockey [51], who conducted research on block-scheduled Mathematics classes, and concluded that teachers, although having a block scheduled class at their disposal, spend on average 66% of the class time for frontal teaching, 33% of the time in the application of what has been learned, and less than 1% of the time for content synthesis. Such time-allocation for individual teaching strategies is not in line with the basic recommendations on the implementation of block class scheduling, which suggest the intensive use of active learning techniques in order to positively affect student success [37].

In the seventh and eighth grades, students taught in block-scheduled classes scored better in both written exams (initial and final) than students who were taught in single-scheduled classes, which finding is consistent with the results of several previous studies [10–12]. However, in the context of the student performance categories considered

in our study, seventh-grade students with medium and good average performances and excellently performing eighth-grade students who were taught in block-scheduled classes did not show improvement in the final exam, compared to the initial assessment. It is likely that the excellent eighth-graders did not learn anything novel in the block-scheduled class compared to what they had adopted via informal learning on a given topic (sexual organs), which could then lead to the absence of improved results in the final exam. In the eighth grade, the interests of preadolescents (i.e., students aged 11 to 13) tend to focus on detailed learning about their own body and sexual organs, and especially about the sexual organs of the opposite sex [52], so it is likely that students gained knowledge on the topic via informal learning. According to Sandoval [53], such topics are motivating for students, which further leads to better performance. One possible cause for the lower final exam score among the seventh-grade students in the present study could be the inadequacy of block-class scheduling for teaching selected topics, namely algae and fungi. These topics include many new taxonomic terms and demand the gradual revision of the new terminology to obtain cumulative learning organization and the formation of new knowledge [50,54], as previously mentioned regarding the sixth-grade content. Furthermore, seventh-graders are "more experienced" in block-class scheduling and possess some prior knowledge that is crucial for learning and properly incorporating new information into the existing knowledge network [55]. This could explain why, in the seventh grade, the low-performing students taught in block-scheduled classes made progress in the final exam, compared to the initial assessment. As proof of this assumption, we can compare the progress between seventh- and fifth-grade students, the latter lacking some prior knowledge and understanding of the principles of single-celled and multicellular organisms (cf. Nature and Society Curriculum, [32]). Among the fifth-grade students, block-scheduled classes resulted in a lower score on the final exam (especially among lower-performing students), while in seventh grade, where students had a greater experience in block-scheduled classes and higher prior knowledge, low-performing students achieved better results in the final exam. This indicates that students with lower prior knowledge need guidance and learning assistance [37], as well as multiple revisions of smaller amounts of information via various methods [39]. As the existing knowledge network upgrades over the years [56], the low-performing students get more used to learning in block-scheduled classes. Since the interaction of scheduling (B or S) and prior knowledge (average student performance) has been proven among seventh-grade students, this can serve as additional evidence that prior knowledge and teaching modes could be good indicators of success, which is consistent with the results of Núñez et al. [57].

Block-scheduled classes present a certain challenge in terms of adapting teaching and learning—both for teachers and students [58]. Many studies state that block class scheduling contributes to the learning level overall, due to the extended class duration that allows for improvement of the methodological and didactic design of the lesson [20,59,60]. However, Rikard and Banville [15] do not confirm such conclusions. Additionally, our previous research [8] found that block class scheduling could also result in lower scores for the lower-performing students. Tenney [61] also states that block-scheduled classes do not necessarily result in improved achievement by lower-performing students (i.e., students with difficulties in maintaining attention), although they can maintain a satisfactory level of achievement. The results of the present study do not clearly indicate that block class scheduling contributes to better student achievements. We suggest that student achievements in block-scheduled classes depend on student age, performance categories and prior knowledge, but also on the lesson microplanning [62]. Due to its prolonged duration, block classes enable the inclusion of numerous teaching and learning activities [3,7,63], and teachers who teach science subjects prefer this type of scheduling because it allows the timely implementation of practical work [3,7]. However, some authors agree that block class scheduling can only be beneficial for student success if the lesson timing is well-planned in terms of changing activities [38,64]. In the present study, student activities were mainly based on observation—a recommended activity in teaching Biology, according

to the CNES guidelines [32]. However, although the CNES guidelines define the teaching topics and desired achievements, they are still not fully and consistently implemented in all schools [65]. Osborne and Dillon [66] also point out that a content-oriented and knowledge-oriented approach continues to dominate science-education practice. This model should be replaced by a student- and concept-centered approach that might be achieved through the effective planning of teaching, which should take into account the interdependence of the students' age, their average performance, prior knowledge, curriculum-specific concepts, and the complexity of the concepts, as well as merely the class scheduling.

5. Conclusions

The implementation of block-scheduled classes is not a guarantee for better student success. Its effect on student achievements can be better assessed by considering the age-related prior knowledge of students, their understanding of curriculum-specific concepts and the complexity of those concepts, as well as average student performance (performance category). Block-scheduled classes result in better student achievement only at the end of primary school (7th and 8th grade), whereas among fifth- and sixth-grade students, single-class scheduling is more effective. This is likely because fifth-graders are transitioning from class- to subject-based teaching, and to the adoption of new and more complex concepts (e.g., cells, cell structure and division, differences between unicellular and multicellular organisms), and sixth-graders have to adopt many new taxonomic and ecological terms that are probably more efficiently taught in smaller fragments, i.e., in a single lesson. These results indicate that, when assessing students' learning success, attention needs to be paid to those students who are at the beginning of a certain educational cycle or at the beginning of learning a novel concept. It is also necessary to pay attention to lower-performing students who need guidance and help in learning. One should not forget about good and excellently performing students as well because, in their case, a block-scheduled class does not necessarily result in additional progress.

Although block-scheduled classes, due to their duration, ensure the completion of the teaching cycle (from achieving the learning outcome to assessing the achievement at the end of the lesson), it is still necessary to revise the content taught in the previous lesson, which is especially important due to the prolonged period between the two block-scheduled classes. This revision is especially important for low-performing students and for teaching concepts that require the adoption of many new terms. By following these guidelines, and by combining single- and block-scheduled classes (depending on the teaching topics) teachers could improve their teaching and, in turn, might further improve students' learning success.

Croatian education is currently introducing new Croatian subject and interdisciplinary curricula, where the implementation of block class scheduling is recommended for achieving learning outcomes in Nature and Biology classes. In addition, many governments are presently considering the implementation of block scheduling as a solution for reducing the number of transitions in a school day and restricting the social interactions among different students and teachers, to conform with guidelines during the COVID-19 pandemic period (e.g., [30,31]). Thus, the results of this research can serve as guidelines for present teachers, practitioners, and legislators in fitting the positive aspects of block-scheduling into the current challenges of school life. This study also contributes to the discussion on the effectiveness of block-scheduled classes on learning success within educational sciences, since a clear effect of class scheduling on student learning success has not yet been determined. For a broader interpretation of our results, it would be necessary to extend this research to other conceptually interconnected STEM subjects. In addition, it would be necessary to investigate in more detail how the application of certain teaching activities in block class scheduling affects the success of students of different ages and performance categories.

Author Contributions: Conceptualization, I.L. and I.R.; methodology, I.L.; validation, I.L. and I.R.; formal analysis, I.L. and M.S.P.; investigation, I.L.; resources, I.L., M.S.P. and I.R.; data curation, I.L.; writing—original draft preparation, I.L. and M.S.P.; writing—review and editing, M.S.P.; visualization,

I.L. and M.S.P.; study administration, I.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Prior to the children's participation in the current study, their parents signed written consent, and the research was permitted by the principals of the participating schools.

Data Availability Statement: The datasets used and/or analysed during the current study are available from the first and/or corresponding author on reasonable request.

Acknowledgments: We would like to thank the principals, students, and Nature and Biology teachers of the primary schools, who were willing to participate in this research. Without them, this study would not have been possible. We are grateful to two anonymous reviewers who provided insightful comments to the earlier versions of this manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Dumont, H.; Istance, D. Analysing and Designing Learning Environments for the 21st Century. In *The Nature of Learning: Using Research to Inspire Practice*; Dumont, H., Istance, D., Benavides, F., Eds.; OECD: Paris, France, 2010; pp. 19–32.
2. Schneider, M.; Preckel, F. Variables associated with achievement in higher education: A systematic review of meta-analyses. *Psychol. Bull.* **2017**, *143*, 565–600. [CrossRef]
3. Gullatt, D.E. Block scheduling: The effects on curriculum and student productivity. *NASSP Bull.* **2006**, *90*, 250–266. [CrossRef]
4. Huelskamp, D. Traditional/block scheduling, gender, and test scores in college biology course. *Learn. Assist. Rev.* **2014**, *19*, 45–51.
5. Marchant, G.J.; Paulson, S.E. Differential school functioning in a block schedule: A comparison of academic profiles. *High Sch. J.* **2001**, *84*, 12–20. [CrossRef]
6. Nichols, J.D. Block-schedule high schools: Impact on achievement in English and language arts. *J. Educ. Res.* **2005**, *98*, 299–309. [CrossRef]
7. Jones, C.A. Science and Block Scheduling an Analysis of Teacher Experiences in Wake County, North Carolina. Ph.D. Thesis, Graduate Faculty of North Carolina State University, Raleigh, NC, USA, 2009.
8. Labak, I.; Sertić Perić, M.; Radanović, I. Effects of block vs. traditional scheduling on high school science success—Lessons from biology classes. *Educ. Sci.* **2020**, *10*, 209. [CrossRef]
9. Veal, W. Teaching and student achievement in science: A comparison of three different schedule types. *J. Sci. Teach. Educ.* **2000**, *11*, 251–275. [CrossRef]
10. Hess, C.; Wronkovich, M.; Robinson, J. Measured outcomes of learning under block scheduling. *NASSP Bull.* **1999**, *83*, 87–95. [CrossRef]
11. Lewis, C.W.; Dugan, J.J.; Winokur, M.A.; Cobb, R.B. The effects of block scheduling on hgh school academic achievement. *NASSP Bull.* **2005**, *89*, 72–87. [CrossRef]
12. Zepeda, S.J.; Mayers, R.S. An analysis of research on block scheduling. *Rev. Educ. Res.* **2006**, *76*, 137–170. [CrossRef]
13. Gruber, C.D.; Onwuegbuzie, A.J. Effect of block scheduling on academic achievement among high school students. *High Sch. J.* **2001**, *84*, 32–42. [CrossRef]
14. Randler, C.; Kranich, K.; Eisele, M. Block scheduled versus traditional biology teaching—an educational experiment using the water lily. *Instr. Sci.* **2008**, *36*, 17–25. [CrossRef]
15. Rikard, G.L.; Banville, D. High school physical education teacher perceptions of block scheduling. *High Sch. J.* **2005**, *88*, 26–34. [CrossRef]
16. Mizhquiri, L. White Paper: The Effects of Block Scheduling and Traditional Scheduling on High School Student Achievement. EDUC 17: What Works in Education? 2019. Available online: https://digitalcommons.dartmouth.edu/educ17whitepapers/1 (accessed on 19 November 2020).
17. Trenta, L.; Newman, I. Effects of a high school block scheduling program on students: A four-year longitudinal study of the effects of block scheduling on student outcome variables. *Am. Second. Educ.* **2002**, *31*, 54–71.
18. Jenkins, E.; Queen, A.; Algozzine, B. To block or not to block: That's not the question. *J. Educ. Res.* **2002**, *95*, 196–202. [CrossRef]
19. Dickson, K.; Bird, K.; Newman, M.; Kalra, N. *What is the Effect of Block Scheduling on Academic Achievement? A Systematic Review*; Technical Report; EPPI-Centre, Social Science Research Unit, Institute of Education, University of London: London, UK, 2010.
20. Williams, C. The Impact of Block Scheduling on Student Achievement, Attendance, and Discipline at the High School Level. Ph.D. Thesis, Argosy University, Atlanta, GA, USA, 2011. Available online: https://eric.ed.gov/?id=ED528899 (accessed on 19 November 2020).
21. Mattox, K.; Hancock, D.R.; Queen, J.A. The effect of block scheduling on middle school students' mathematics achievement. *NASSP Bull.* **2005**, *89*, 3–13. [CrossRef]
22. Perry, C.; Allard, A. Making the connections: Transition experiences for first-year education students. *J. Educ. Enq.* **2003**, *4*, 74–89.

23. Ziapour, A.; Sharma, M.; NeJhaddadgar, N.; Mardi, A.; Tavafian, S.S. Educational needs assessment among 10–14-year-old girls about puberty adolescent health of Ardebil. *Arch. Public Health* **2020**, *78*, 5. [CrossRef]
24. Eccles, J.S.; Lord, S.; Midgley, C. What are we doing to early adolescents? The impact of educational contexts on early adolescents. *Am. J. Educ.* **1991**, *89*, 521–542.
25. Hell, B.; Trapmann, S.; Schuler, H. Eine Metaanalyse der Validität von fachspezifischen Studierfähigkeitstests im deutschsprachigen Raum. A metaanalysis regarding the validity of academic aptitude tests in Germany. *Empir. Pädagogik* **2007**, *21*, 251–270.
26. Robbins, S.B.; Lauver, K.; Le, H.; Davis, D.; Langley, R.; Carlstrom, A. Do psychosocial and study skill factors predict college outcomes? *A meta-analysis. Psychol. Bull.* **2004**, *130*, 261–288. [CrossRef] [PubMed]
27. Loehr, J.F.; Almarode, J.T.; Tai, R.H.; Sadler, P.M. High school and college biology: A multi-level model of the effects of high school courses on introductory course performance. *J. Biol. Educ.* **2012**, *46*, 165–172. [CrossRef]
28. Thompson, R.A.; Zamboanga, B.L. Prior knowledge and its relevance to student achievement in introduction to psychology. *Teach. Psychol.* **2003**, *30*, 96–101. [CrossRef]
29. Hailikari, T.; Nevgi, A.; Lindblom-Ylänne, S. Exploring alternative ways of assessing prior knowledge, its components and their relation to student achievement: A mathematics based case study. *Stud. Educ. Eval.* **2007**, *33*, 320–337. [CrossRef]
30. GSESNI. Coronavirus (COVID-19): Guidance for Schools and Educational Settings in Northern Ireland. Department of Education. Available online: www.education-ni.gov.uk (accessed on 19 November 2020).
31. MSE. *Models and Recommendations for Work in Conditions Associated with COVID-19 Disease*; Ministry of Science and Education of the Republic of Croatia: Zagreb, Croatia, 2021.
32. MZOŠ. *Nastavni Plan i Program za Osnovnu Školu*; Ministarstvo znanosti, obrazovanja i športa: Zagreb, Croatia, 2006.
33. Grgin, T. *Školska Dokimologija (Drugo Promijenjeno Izdanje)*; Naklada Slap: Jastrebarsko, Croatia, 1994.
34. Garašić, D.; Radanović, I.; Lukša, Ž. Usvojenost makrokoncepata biologije tijekom učenja u osnovnoj školi i gimnaziji. In *Metodike u Suvremenom Odgojno-Obrazovnom Sustavu*; Milanović, D., Bežen, A., Domović, V., Eds.; Akademija odgojno-obrazovnih znanosti Hrvatske: Zagreb, Croatia, 2013; pp. 211–239.
35. Bonner, T.A. Comparison of the Effects Block and Traditional Schedules Have on the Number of Students Who Are Proficient on the Biology End-of-Course Test in Forty Public High Schools in the State of North Carolina. Ph.D. Thesis, Liberty University, Lynchburg, VA, USA, 2012. Available online: https://digitalcommons.liberty.edu/doctoral/522 (accessed on 19 November 2020).
36. Dostal, J.R. Alternative Scheduling Models and Their Effect on Science Achievement at the High School Level. Ph.D. Thesis, The Graduate College, University of Nebraska, Omaha, NE, USA, 2010.
37. Canady, R.L.; Rettig, M.D. The power of innovative scheduling. *Educ. Leadersh.* **1995**, *53*, 4–10.
38. Queen, J.A. Block scheduling revisited. *Phi Delta Kappan* **2000**, *82*, 214–222. [CrossRef]
39. Thomas, C. What is wrong with block scheduling? *NASSP Bull.* **2001**, *85*, 74–77. [CrossRef]
40. Keller, B.J. Effect of Three Different Types of High School Class Schedule (Traditional, Rotating Block, and Accelerated Block) on High School Biology Achievement and on Differences in Science Learning Environments. Ph.D. Thesis, University of North Texas, Denton, TX, USA, 1997.
41. Allen, D.; Tanner, K. Infusing active learning into the large-enrollment biology class: Seven strategies, from the simple to complex. *Cell Biol. Educ.* **2005**, *4*, 262–268. [CrossRef]
42. Felder, R.M.; Brent, R. Navigating the bumpy road to student-centered instruction. *Coll. Teach.* **1996**, *44*, 43–47. [CrossRef]
43. Kyriacou, C. *Effective Teaching in Schools*; Stanley Thornes Ltd.: Cheltenham, UK, 1995.
44. Lindsay, J. The Case Against Block Scheduling. 2013. Available online: https://www.jefflindsay.com/Block.shtml#intro (accessed on 19 November 2020).
45. Lazarowitz, R.; Penso, S. High school students' difficulties in learning biology concepts. *J. Biol. Educ.* **1992**, *26*, 215–223. [CrossRef]
46. Driver, R.; Squires, A.; Rushworth, P.; Wood-Robinson, V. *Making Sense of Secondary Science: Research into Children's Ideas*; Routledge: London, UK, 1994.
47. Sewell, A. Constructivism and student misconceptions: Why every teacher needs to know about them. *Aust. Sci. Teach. J.* **2002**, *48*, 24–28.
48. Trefil, J.; Calvo, R.A.; Cutler, K.; Littell, M. *McDougal Littell Life Science*; McDougal Littell: Evanston, IL, USA, 2006.
49. Karlsson, G. Instructional Technologies in Science Education: Students' Scientific Reasoning in Collaborative Classroom Activities. Ph.D. Thesis, University of Gothenburg, Gothenburg, Sweden, 2012.
50. Yang, J.; Zhan, L.; Wang, Y.; Du, X.; Zhou, W.; Ning, X.; Sun, Q.; Moscovitch, M. Effects of learning experience on forgetting rates of item and associative memories. *Learn. Mem.* **2016**, *23*, 365–378. [CrossRef] [PubMed]
51. Shockey, B.P. The Effects of Varying Retention Intervals within a Block Schedule on Knowledge Retention in Mathematics. Ph.D. Thesis, University of Maryland, College Park, MD, USA, 1997.
52. Mrnjaus, K. Vrjednovanje programa spolnog odgoja s pedagoškog stajališta. *Riječki Teološki Časopis* **2014**, *44*, 293–320.
53. Sandoval, J. Teaching in subject matter areas: Science. *Annu. Rev. Psychol.* **1995**, *46*, 355–374. [CrossRef]
54. Bharadwaj, K.K.; Kandwal, R. Cumulative learning techniques in production rules with fuzzy hierarchy (PRFH) system. *J. Exp. Theor. Artif. Intell.* **2008**, *20*, 111–132. [CrossRef]
55. Sewell-Smith, A. Teaching does not necessarily equal learning. *Teach. Sci. J. Aust. Sci. Teach.* **2004**, *50*, 22.
56. Dochy, F.; de Rijdt, C.; Dyck, W. Cognitive prerequisites and learning: How far have we progressed since Bloom? Implications for educational practice and teaching. *Act. Learn. High. Educ.* **2002**, *3*, 265–284. [CrossRef]

57. Núñez, J.C.; Vallejo, G.; Rosário, P.; Tuero, E.; Valle, A. Student, teacher, and school context variables predicting academic achievement in biology: Analysis from a multilevel perspective. *J. Psychodidactics* **2013**, *19*, 145–172. [CrossRef]
58. Dorwin, N. Teachers' Opinions and Attitudes toward Block Scheduling. Master's Thesis, University of Wisconsin-Stout, Menomonie, WI, USA, 2009. Unpublished Work.
59. Kaya, S.; Aksu, M. The advantages and disadvantages of block scheduling as perceived by middle school students. *J. Educ. Instr. Stud. World* **2016**, *6*, 50–59.
60. Mamon, V. An Analysis of Secondary School Teachers' Perceptions of Block Scheduling. Master's Thesis, Georgia Southern University, Statesboro, GA, USA, 2012. Available online: https://digitalcommons.georgiasouthern.edu/etd/795 (accessed on 19 November 2020).
61. Tenney, M.G. The Effects of Block Scheduling on Students with Emotional Behavioral Disorders and/or Attention Deficit-Hyperactivity Disorder. Master's Thesis, Notre Dame College, South Euclid, OK, USA, 1998. Available online: https://eric.ed.gov/?id=ED426567 (accessed on 19 November 2020).
62. Robbins, P.; Gregory, G.; Herndon, L.E. *Thinking Inside the Block Schedule: Strategies for Teaching in Extended Periods of Time*; Corwin Press: Thousand Oaks, CA, USA, 2000.
63. Weller, D.R.; McLeskey, J. Block scheduling and inclusion in a high school: Teacher perceptions of the benefits and challenges. *Remedial Spec. Educ.* **2000**, *21*, 209–218. [CrossRef]
64. Kilpatrick, R.M. Block scheduling strategies and perceptions. *J. Stud. Educ.* **2014**, *4*, 20. [CrossRef]
65. Garašić, D.; Radanović, I.; Lukša, Ž. Osvrt na aktualne nastavne programe učenja biologije. *Napred. Časopis Za Pedagog. Teor. I Praksu* **2018**, *159*, 179–194.
66. Osborne, J.; Dillon, J. Science Education in Europe: Critical Reflections. 2008. Available online: https://www.researchgate.net/publication/252404504_Science_Education_in_Europe_Critical_Reflections (accessed on 19 November 2020).