Article

Self-Regulated Learning in Science Classes with a Discovery Learning Environment and Collaborative Discovery Learning Environment

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Abstract: The study aims to compare how discovery learning and collaborative discovery learning affect knowledge acquisition, the development of understanding through phases of self-regulated learning (SRL), and the use of SRL strategies at the individual level. The sample consists of 981 eleven-year-old students. The results show that both methods have a positive effect on knowledge acquisition. Collaborative discovery learning has more positive effects on the development of students’ understanding by developing collaborative skills. Motivational strategies (especially in girls) are more developed in collaborative discovery learning than in discovery learning. Students who show more pronounced negative characteristics of self-regulation also achieve poorer results in the knowledge test, and this is more pronounced in students who have participated in discovery learning. The tendency of an affirmative attitude towards the characteristics of SRL in the entire population of students indicates a proportional growth in accordance with success in learning, but in more successful students, it indicates a uniform retention of an affirmative attitude. The tendency toward an affirmative attitude regarding the characteristics of collaborative learning is inversely proportional to students’ success, with a more pronounced attitude decrease in more successful students.

Keywords: development of understanding; group learning; learning environment

1. Introduction

Self-regulated learning (SRL) represents one of the key competencies needed for successful action in modern society [1,2]. SRL is most often explained at the individual level, where learning is viewed as an independent, purposeful, and permanent acquisition of knowledge to improve skills and abilities [3]. SRL consists of three main components: cognition (skills needed to code and memorize information), metacognition (skills that allow for understanding and observing one’s cognitive process and motivation), and motivation (beliefs and attitudes that affect the use and development of cognitive and metacognitive skills) [3]. During SRL, students must analyze the task, choose strategies to solve the learning challenge, and set learning goals (planning phase); adjust their plan with self-monitoring of progress and activate inclusion strategies in task creation (implementation phase); and evaluate their learning (evaluation phase) [4]. All of this leads to the creation of better work habits and the improvement of learning skills [3]. Research conducted in Croatia on primary school students shows that students do not have developed learning habits and mostly learn just before an examination [5]. Ristič Dedić and Jokić [5] conclude that such patterns are extremely harmful to the development of learning competencies, and there is a great need to implement SRL in teaching.

According to Järvelä and Järvenoja [6], SRL can be viewed from three perspectives:
1. Socio-cognitive perspective: at the center is the individual and how he/she regulates their cognition, motivation, and behavior to accelerate the learning process; the focus of the analysis is the individual and his/her performance in a social context;

2. Socio-cultural perspective (coregulation): this involves the sharing of facts, ideas, goals, and activities through joint interaction, and the focus of the analysis is the social and cultural structure of learning;

3. Situational perspective (co-construction): this observes the regulation of learning at the individual and social levels, where both levels are balanced and interdependent.

In the past two decades, there has been a proliferation of research on SRL, from which it can be derived that SRL is positively associated with learning behavior, achievement, and motivation [7–9]. Currently, there is still little known about environments that foster SRL [10,11]. As learning takes place in a social environment where students interact with each other, there is a growing interest in observing SRL in a collaborative environment that enables the exchange of ideas. Most of these studies deal with students’ learning, emotions, motivation, and shared regulation [2,6,12]. However, some studies show that collaborative learning can be very demanding for students due to the cognitive load [13]. Collaborative learning uses independent tasks that require joint decision making on the methods and strategies to be applied to achieve a common goal, as well as procedures for determining whether selected strategies, methods, and learning techniques are achieving a given goal with little or no intervention from teachers [14]. Through such procedures, students learn how to regulate their learning and the learning of the whole group [14], which can be very challenging [13]. In this study, we compare discovery learning and collaborative discovery learning, both in which students are active learners and learn in groups, but with a difference in collaborative learning being that it does not employ teacher guidance. More precisely, we compare the following: (1) the development of student understanding on an individual level during the three stages of SRL; (2) the level of conceptual understanding after learning; and (3) the cognitive, emotional, and motivational strategies used in the discovery learning environment and collaborative discovery learning environment.

The study aims to compare how discovery learning and collaborative discovery learning affect knowledge acquisition, the development of understanding through phases of SRL, and the use of learning strategies at the individual level. To achieve the aim of the study, the following hypotheses were set:

**H1:** Students learning through collaborative discovery learning during SRL use knowledge at statistically significantly higher levels of understanding compared to students learning through discovery learning.

**H2:** Students learning through collaborative discovery learning apply statistically significantly more SRL strategies than students learning through discovery learning.

**H3:** Students learning through collaborative discovery learning show statistically significantly more characteristics essential for SRL and collaborative learning compared to students learning through discovery learning.

**H4:** Students learning through collaborative discovery learning perform statistically significantly better in problem solving, conceptual understanding, and the application of knowledge compared to students learning through discovery learning.

**H5:** Boys and girls use knowledge and apply SRL strategies equally, possess the same characteristics essential for SRL and collaborative learning, and achieve the same results in a written test of their knowledge.
2. Materials and Methods

The convenient sample consisted of 981 eleven-year-old students from 20 elementary schools from all over Croatia. Non-stimulated SRL was investigated in the sense that students were not particularly stressed about the tasks and meaning of SRL, nor were the students encouraged to self-regulate learning more than usual. The study included 492 girls and 489 boys. The students were divided into two groups: experimental and control, according to their teachers’ choice. The experimental group participated in collaborative discovery learning, and the control group participated in discovery learning in Science classes.

Learning for both groups was carried out in the form of group work. The research was conducted during three series of tasks about soil in the Science class. To ensure unambiguity in teaching, teachers used specifically prepared learning materials that helped them implement discovery learning and collaborative discovery learning in the form of group work. For the control group, the tasks were well structured with teacher guidance, and for the experimental group, the tasks were ill structured with no or little teacher guidance. After learning, students filled out the questionnaire and took the knowledge test (Figure 1).

![Figure 1. Experimental procedure.](image)

CONTROL GROUP
well-structured tasks; teacher guidance

<table>
<thead>
<tr>
<th>1st task</th>
<th>2nd task</th>
<th>3rd task</th>
<th>Knowledge test</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 min</td>
<td>90 min</td>
<td>90 min</td>
<td>Questionnaire</td>
</tr>
</tbody>
</table>

EXPERIMENTAL GROUP
ill-structured tasks; little or no teacher guidance

2.1. Learning Tasks

Three series of tasks were prepared according to the GLOBE Program soil protocols and learning outcomes of the 5th grade Science curriculum in Croatia [15,16]. The tasks guided students through three phases of SRL: planning, implementation, and evaluation (Figure 2), according to Panadero and Alonso-Tapia [17]. The tasks were the same for both groups; only the control group had more structured tasks guided by the teacher, and the experimental group was much more independent.

In the first series of tasks (Figure 2), in the planning phase (P1), the students were supposed to answer the following questions: Why is soil research important? and What can we research about soil? In the implementation phase (I1), the students were supposed to research the structure and properties of the soil through experimentation. In the final phase...
of learning (E1), the students were required to evaluate the selected learning strategies and the results achieved.

<table>
<thead>
<tr>
<th>1st series</th>
<th>2nd series</th>
<th>3rd series</th>
</tr>
</thead>
<tbody>
<tr>
<td>• planning 1 (P1):</td>
<td>• planning 2 (P2):</td>
<td>• planning 3 (P3):</td>
</tr>
<tr>
<td>state the reasons and</td>
<td>test the infiltration</td>
<td>explain behavior of</td>
</tr>
<tr>
<td>possible methods for the</td>
<td>of three different types of</td>
<td>earthworm during rain</td>
</tr>
<tr>
<td>soil research</td>
<td>soil</td>
<td></td>
</tr>
<tr>
<td>• implementation 1 (I1):</td>
<td>• implementation 2 (I2):</td>
<td>• implementation 3 (I3):</td>
</tr>
<tr>
<td>prove the structure and</td>
<td>make a graphic representation based on the results</td>
<td>summarize earthworm behavior in different living conditions</td>
</tr>
<tr>
<td>properties of the soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• evaluation 1 (E1):</td>
<td>• evaluation 2 (E2):</td>
<td>• evaluation 3 (E3):</td>
</tr>
<tr>
<td>evaluate achieved learning</td>
<td>summarize knowledge in the form of Venn diagrams</td>
<td>reflect and comment on learning progress</td>
</tr>
</tbody>
</table>

Figure 2. Analysis based on three series of tasks through three phases of self-regulated learning (SRL) and activity outcomes.

In the second series of tasks (Figure 2), in the planning phase (P2), the students designed an experiment to check the infiltration rates of three different soil types. In the implementation phase (I2), the students were supposed to make a graphical representation based on the results of the experiments. In the evaluation phase (E2), the students summarized and compared the acquired knowledge using Venn diagrams and explained which soil sample represents a better animal habitat, pointing out what would happen if floods occurred in certain areas where such types of land exist.

In the third series of tasks (Figure 2), during planning (P3), the students were supposed to discuss the behavior of an earthworm during and after the rain and design experiments to explain it. In the implementation phase (I3), the students draw an earthworm and observe its behavior in different living conditions. At the evaluation phase (E3), the students were required to reflect on their learning and comment on what they learned.

To see progress in understanding, we summarized the values of partial conceptual understanding and conceptual understanding achieved within the phase of a particular series of tasks (e.g., planning 1). The achieved percentage value of understanding for each phase of a particular series was subtracted from the value of realized understanding in the next phase of SRL (e.g., P1–I1; P1–E1; I1–E1). The Kruskal–Wallis test was used to determine the differences between the experimental and control groups for the individual stages of each task series.

2.2. Knowledge Test

After the teaching, the students wrote a test of their knowledge. Adjusted cognitive levels of knowledge were determined according to Crooks [18], as described in Radanović et al. [19]. Six tasks with eleven parts were selected for the paper’s needs. Two particles checked the first cognitive level of knowledge (cognitive level I: reproduction), seven particles checked the second cognitive level (cognitive level II: application of knowledge and conceptual understanding), and two particles checked the third cognitive level (cognitive level III: problem solving). The coefficient of reliability is acceptable ($\alpha = 0.760$). The student responses were encoded and evaluated according to accuracy criteria and the level of understanding (achievement classes). The cognitive quality of the responses in open-type tasks was determined using specific coding of biological significance, according to Radanović et al. [20]. The Kolmogorov–Smirnov test was used to determine the differences
in solving tasks of different cognitive levels between experimental and control groups and between boys and girls. Linear regression was used to observe the tendency to change the characteristics of self-regulated and collaborative learning based on questionnaire responses in relation to the knowledge test results.

2.3. Questionnaire

The Motivated Strategies for Learning Questionnaire (MSLQ; [21]) and the Achievement Emotions Questionnaire (AEQ; [22]) were modified according to targets of regulation in the collaborative environment to assess the use of learning strategies in collaborative learning tasks [23]. The survey uses a 4-point Likert-type scale (1 = strongly disagree, 4 = strongly agree) and is composed of 24 questions. The questions were classified following the essential descriptors of the cognitive, emotional, and motivational SRL components according to Järvelä et al. [23] (Table 1). Students completed the questionnaire via the online Google Forms in Science class using a tablet device. The coefficient of reliability is acceptable ($\alpha = 0.616$).

To determine the impacts of the applied learning methods on the student characteristics important for self-regulated and collaborative learning, quantitative indicators were extracted from the questionnaire (Table 2).

<table>
<thead>
<tr>
<th>Component</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
<td>I use different ways of learning to learn Science. When I learn Science, I always try to discover the main idea or thought. I apply knowledge from Science a lot in activities such as projects, discussions, and experiments. When I learn Science, I make schemes, maps, drawings, and tables. When I learn Science, I draw what I need to learn. I try to be successful in Science even if I don’t like what we’re learning. When I learn Science, I use different sources of information.</td>
</tr>
<tr>
<td>Motivational</td>
<td>I try hard to learn Science. Science is an interesting subject. The Science teacher comes up with interesting tasks that encourage us to work and learn. Knowledge from Science will benefit me in other subjects.</td>
</tr>
<tr>
<td>Emotional</td>
<td>I am confident expressing my opinion during conversations because of teacher support. I don’t like to work with some classmates. I am proud because we are united as a class. I enjoy learning Science together with the students in the classroom.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Characteristics of the Student</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-regulated learning</td>
<td>When I learn Science, I always try to discover the main idea or thought. When I learn Science, I use different sources of information. When I learn Science, I make schemes, maps, drawings, and tables. When I learn Science, I draw what I need to learn. I apply knowledge from Science a lot in activities such as projects, discussions, and experiments. I try to be successful in Science even if I don’t like what we’re learning. I’m trying to connect Science’s material to other subjects. I try hard to learn Science. I use different ways of learning to learn Science. Knowledge from Science will benefit me in other subjects. Science is an interesting subject.</td>
</tr>
</tbody>
</table>

Table 1. Questions classified in accordance with each component of SRL in the collaborative environment.

Table 2. Questions that indicate student characteristics that are important for SRL and collaborative learning.
Table 2. Cont.

<table>
<thead>
<tr>
<th>Characteristics of the Student</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative learning</td>
<td>I enjoy learning Science together with the students in the classroom.</td>
</tr>
<tr>
<td></td>
<td>I don’t like to work with some classmates.</td>
</tr>
<tr>
<td></td>
<td>I am proud because we are united as a class.</td>
</tr>
</tbody>
</table>

Due to inhomogeneous variances, the Kruskal–Wallis test was used to determine the differences in the use of knowledge and applied strategies during SRL between the experimental and control groups. The Mann–Whitney test was used to determine the differences in applied strategies during SRL and the student characteristics important for SRL and collaborative learning between genders.

3. Results

Discovery learning about soil, regardless of the method used, was well accepted by students. In the P1 phase, more than half of all students (63%) used their knowledge at the level of recognition, of which 11.54% were in the control group, and 3.57% were in the experimental group. In the I1 and E2 phases, the students in the experimental group showed a higher level of understanding than the students in the control group (Figure 3).

For the first series of tasks, the Kruskal–Wallis test did not show significant differences between the experimental and control groups. The results indicate that students, both in discovery learning and collaborative discovery learning, advance in knowledge and learn during the learning process, with collaborative discovery learning encouraging the use of knowledge at higher levels of understanding (Figure 3).

In the P2 phase, 98% of all students showed conceptual understanding. Almost half of the students did not participate in this phase of SRL, which indicates that when the results are presented collectively, the students are prone to social loafing. In the I2 phase, only 11% of students used their knowledge at the level of understanding, of which 12.45% were in the experimental group, and 7.95% were in the control group. In the E2 phase, 69% of students used their knowledge at the level of understanding, of which 88.72% were in the experimental group, and 68.70% were in the control group (Figure 3).

In the second series of tasks, the Kruskal–Wallis test showed statistically significantly more successful planning \( (\chi^2 = 183.521; p < 0.001) \) and evaluation \( (\chi^2 = 18.415; p < 0.001) \) for the control group and statistically significantly more successful implementation of the research for the experimental group \( (\chi^2 = 475.858; p < 0.001) \).

During the P3 phase, 84% of students used their knowledge at the level of understanding. Slightly more students in the experimental group used their knowledge at the conceptual level (Figure 3). In the I3 and E3 phases, all or almost all students used their knowledge at the level of understanding (Figure 3).

For the third series of tasks, the Kruskal–Wallis test showed statistically significantly greater achievement of understanding in all three phases of SRL for the experimental group.
The results are as follows: planning ($\chi^2 = 374.468; p < 0.001$), implementation ($\chi^2 = 476.360; p < 0.001$), and evaluation ($\chi^2 = 425.520; p < 0.001$).

Students who studied through collaborative discovery learning scored statistically significantly better in most (6 out of 9) phases of SRL. The largest positive difference compared to the control group was achieved in the E2 phase (20%). The largest difference with the dominance of the control group was recorded during the P1 phase (8%). The control group was more successful during the P2 phase (4%) and the E3 phase (2%) (Figure 3). Both groups of students achieved the lowest score in the I2 phase ($M = 10.20 \pm 3.18$) and were most successful in the E3 phase ($M = 98.45 \pm 1.64$). Despite the poor success, in the I2 phase, there was a smaller decrease in the achieved understanding in the experimental group (Figure 3). Both groups achieved the weakest development of understanding between the P2 and I2 phases. The students made the greatest progress in understanding from the I2 to the E2 phase (Figure 3).

From the results, we can see that the students started their learning using knowledge at the level of recognition (series 1). As learning progressed, the students adapted to the discovery way of learning and, over time (series 3), learned how to use knowledge at the level of understanding, with a slight advantage in students who learned through collaborative discovery learning, especially in the evaluation phase (Figure 4).

Both learning methods can be assessed as successful, as understanding and applicable levels of cognition were achieved in all series of tasks. Only 3% of students showed misunderstanding, 26% achieved learning at the level of reproduction and recognition, and 71% showed conceptual understanding in a complete or partial form (Figure 5).
Girls in the control group were statistically significantly more successful compared to other students in learning during the I2 phase ($\chi^2 = 4.646; p < 0.05$) and the I3 phase ($\chi^2 = 4.390; p < 0.05$).

Both groups of students solved the knowledge test satisfactorily, i.e., 67% of students successfully solved over 50% of the written knowledge test. The students best solved the tasks of cognitive level I (Figure 6). The experimental group of students solved the test better at all cognitive levels (Figure 6). Despite the visible differences in favor of collaborative discovery learning, the Kolmogorov–Smirnov test did not show a significant difference between the learning methods or gender, which indicates that regardless of the learning method, discovery learning enables quality learning.

![Figure 6. Analysis of achievement on the knowledge test according to the learning method: Student’s average achievement according to the way of learning and cognitive levels (CL)](image)

As for the SRL components, the Kruskal–Wallis test indicated significant differences with regard to the influence of the motivational factor between the experimental and control groups of students ($\chi^2 = 21.431; p < 0.001$). Within the cognitive and emotional components, there were no significant differences between the groups.

Both groups show characteristics important for SRL and collaborative learning. According to the Kruskal–Wallis test, a significant difference was established in students’ opinions on the possibility of collaborative learning within their class ($\chi^2 = 12.907; p < 0.001$). The Mann–Whitney test showed that girls use the motivational component of SRL more than boys ($z = −3.772; p < 0.001$) and show more characteristics associated with SRL than boys ($z = −2.285; p < 0.05$).

The control group students, with low achievement levels on the test, showed more negative characteristics related to SRL than the experimental group (Figure 7).

In the experimental group, the students with the greatest success in the test showed positive characteristics related to SRL and collaboration. In both groups, it was observed that the students with a medium achievement level (from 50% to 70%) mostly showed positive characteristics related to SRL. The control group students, who solved the test from 55% to 75%, showed more negative characteristics related to collaboration. The most successful students in the experimental group showed fewer positive characteristics related to collaborative learning.

The tendency towards an affirmative attitude regarding the mean values of the characteristics of SRL grows from the lowest to the highest achievement level (Figure 8). Growth is pronounced in students up to 30% of the achievement on the knowledge test, and for higher levels, it is balanced in the mean value of $3.56 \pm 0.04$, but with a weak effect in relation to the achievement level. The tendency towards an affirmative attitude regarding the mean values of the characteristics of collaborative learning falls from the lowest to the highest
achievement level (Figure 8). The coefficient of determination of the linear regression for the characteristics of collaborative learning indicates an intermediate to strong effect in relation to the achievement levels.

![Distribution of students according to achievement levels within the characteristics of SRL in experimental and control group (* extreme outlier, ° mild outlier).](image)

**Figure 7.** Distribution of students according to achievement levels within the characteristics of SRL in experimental and control group (* extreme outlier, ° mild outlier).

![Tendencies to change the characteristics of SRL and collaborative learning based on questionnaire responses in relation to achievement classes.](image)

**Figure 8.** Tendencies to change the characteristics of SRL and collaborative learning based on questionnaire responses in relation to achievement classes.

### Discussion

The students who participated in collaborative discovery learning achieved better results in most phases of SRL. The students relied on each other and coordinated their knowledge by sharing ideas through all three phases of learning, thus developing an understanding better than the control group. Sun et al. [24] also came to the conclusion that collaboration enables the integration of social skills by encouraging the establishment of a common understanding and team organization. Panadero and Järvelä [25] and Webb and Mastergeorge [26] also concluded in their research that SRL in a collaborative environment leads to better learning and the development of understanding. Isohätälä [27] argues that students, during the collaboration process, can mutually influence engagement and regulation processes and coordinate learning. Panadero et al. [28] argue that collaboration does not guarantee success, and in order to promote such learning, educators need to
provide tools for facilitating and enhancing shared regulation in the group, which the educators in our study have managed to accomplish through specially designed learning materials. Radkowitsch et al. [29] reported in their research that some students are not satisfied with the collaborative way of learning, because they notice that some students do not take part in assignments, so this behavior demotivates students who invest effort. During this study, the teachers and students also reported this phenomenon, which was most evident in the second series of tasks and influenced the results of the research. This phenomenon is called social loafing [30] and could be diminished or even prevented by evaluating each student. Varela et al. [31] emphasize the need for teachers to create a belief that no member of the group has all the abilities to perform a given task alone and, in that way, create a positive atmosphere for collaboration.

A slight advantage of the control group in the P1 and P2 phases is possible due to the difficult organization of such a form of learning and the need for detailed preparation by teachers and students [29]. Also, students need a certain amount of time to accept the new way of learning, so it is possible that they achieved weaker results at the beginning of learning than the control group. The advantage of the control group in the P1 and P2 phases is supported by the research of Wang et al. [32], which showed how collaborative work materials can increase student activities during the implementation and evaluation phases but do not affect the planning phase. Their conclusion is that working materials reduce the need for planning but provide more opportunities to monitor the progress of the task or make it easier for students to use self-regulation through the promotion of co-regulatory processes. In the I1 phase, the experimental group was more successful, which proves that students are motivated to work when they work on their own, try to devise ways to come up with solutions, and have the opportunity to actively use the knowledge acquired through previous learning.

A better understanding of tasks is visible as learning progresses. The students used metacognitive skills more effectively, so they planned, implemented, and evaluated their work in the third series of tasks more successfully than they did at the beginning of learning. The students adapted to the discovery way of learning and, over time, learned to use knowledge at the level of understanding, with a slight advantage in students who learned through collaborative discovery learning, especially in the E2 phase. Specially designed tasks in the experimental group contributed to this, where the students had to independently choose methods to come up with a solution and developed a common awareness of goals, tasks, and progress as a group. Eilam and Reiter [33] found that students at the beginning of learning put most of their effort into tasks that did not require greater cognitive effort, focusing on mechanically filling tables and completing reports. But as time progressed, they began to put more effort into regulating learning. The results of this study could indicate the importance of the extensiveness and length of the task for using knowledge at higher cognitive levels and the motivation of students to regulate their learning. It should also be mentioned that both groups of students showed the least understanding in the I2 phase, in which they were asked to prepare a graphical representation based on the results of experiments. Less success in the I2 phase may be because students are very rarely required to complete such tasks in early learning [34]. A minor decline in understanding was observed in the experimental group. Such results suggest that a greater involvement of students in the process of planning experiments helped them to achieve a better understanding, although they did not cope with learning during the implementation of the experiment.

The research showed that both groups of students achieved the same level of knowledge during learning, with a slight advantage in students who participated in collaborative discovery learning. Such results indicate that both methods have a positive effect on knowledge acquisition, which is confirmed by research such as that of Lehtinen et al. [35]. A slightly better result in the knowledge test of students who participated in collaborative discovery learning is confirmed by the research of Radkowitsch et al. [29], which shows that students who are not guided by a teacher throughout the learning process develop
the skills of planning, monitoring, and evaluating their own performance, which leads
to better achievements during learning. Tzimas and Demetriadis [36] came to an oppo-
site conclusion, where teacher guidance positively affected on SRL skills. Radkowitsch
et al. [29] also came to the conclusion that joint regulation leads to greater reflection on the
most important features of the task, which in turn leads to better learning outcomes.

As for the SRL components, a statistically significant difference was found only for
the motivational component. These results agree with the conclusions of Pietryka and
Glazier [14], who argued that collaboration encourages student motivation, which then
leads to better communication between students during learning. Nevertheless, motivation
in a collaborative environment can also be reduced when students’ goals and requirements
do not coincide [29], as happened in the I2 phase of our research, so students solved the task
at the level of application and recognition. Girls use more motivational strategies for learn-
ing than boys. Hutchinson et al. [37] also reported that girls use self-regulating strategies to
a greater extent than boys, while Schweder and Raufelder [38] reported higher values for
boys for introjected and extrinsic motivation regulation. For other components (emotional
and cognitive), differences have not been found. Such results confirm that students are
happy to learn in discovery learning and collaborative discovery learning environments.

As for the characteristics essential for SRL and collaborative learning, the results show
that students who have learned through collaborative discovery learning believe that they
can learn together with classmates, which indicates that collaborative discovery learning
encourages the development of collaborative skills, which is confirmed by other research
works [39,40].

It has been shown that the regulation of learning at the individual level affects the
results of the knowledge test. Students who show more pronounced negative behavioral
characteristics within the framework of self-regulation also achieve poorer results on the
knowledge test, and this is more pronounced in students who participated in discovery
learning. Such a conclusion is confirmed by studies that have shown that cognitive and
metacognitive abilities [24] and motivation [2] develop in a collaborative environment, and
these are factors that are essential for SRL [2]. Students who are more successful in solving
knowledge tests have more positive characteristics of self-regulation while collaborative
characteristics decrease, unlike students with weaker abilities who progress more in a
collaborative discovery learning, and this has been confirmed by some other studies that
says that excellent students do not benefit as much from collaborative learning as weaker
students do [41].

5. Conclusions

Both methods have a positive impact on knowledge acquisition. If implemented
well, collaborative discovery learning promotes the development of SRL awareness and
the understanding of tasks more than discovery learning. Students who learn through
collaborative discovery learning are more successful in the learning process, but it is
necessary to practice such a way of learning with students in order to acquire the skills
necessary for successful learning. Collaborative discovery learning raises awareness of the
benefits of collaborative learning within the classroom, has a more positive effect on the
usage of motivational strategies by students than discovery learning, especially girls, but
there are no differences compared to boys when solving knowledge test tasks. Students
who show more pronounced negative behavioral characteristics within the framework of
self-regulation also achieve poorer results in the test of knowledge, and this is more
pronounced in students who have not participated in collaborative discovery learning.
It was noticed that students who were more successful in solving the knowledge test
had more positive characteristics of self-regulation and could learn on their own, unlike
students with weaker abilities who progressed more in a collaborative discovery learning.
It was observed that some of the students did not use their knowledge for joint learning,
and it is necessary to pay special attention to the equal distribution of work among all
modules of a group or to adapt partial tasks to a student’s abilities and interests so that each student can contribute to joint learning.

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**Institutional Review Board Statement:** The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Ministry of Science and Education of Croatia (602-02/19-03/00464; 533-05-19-0004, date of approval: 3 December 2019).

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy and confidentiality agreements.

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

**References**