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A SCHOOL GARDEN IN BIOTECHNICAL EDUCATION

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Abstract - This study was conducted on a sample of 360 students of biotechnical education aged 15 to 18 with the aim of testing the effectiveness of experiential instruction in a school garden in comparison with traditional instruction in a classroom. The results show that experiential instruction yielded significantly better achievement scores than traditional teaching. The experiential instruction group scored higher in both cognitive domains included in the test, i.e. knowing and applying. Students' knowledge in a post-test was influenced by gender, grade and the educational program that students were enrolled in.

Key words: School garden, experiential learning, secondary school, academic achievement, freshwater ecosystem

INTRODUCTION

All through history, providing food was one of the most decisive factors for the survival of humankind. Because of this, the population was educated about food production, gardens at schools were organized, and separate agricultural schools were formed. Over time, the content, purpose and prevalence of school gardens changed. Today, after decades of decline, we find that there is a growing movement among educators in many countries around the world to include gardens as a teaching tool within schools (Cutter-Mackenzie, 2009; Ratcliffe et al., 2011; Subramaniam, 2002). Mostly revived are gardens at the primary and middle school levels, and somewhat less at the high school level. As Graham et al. (2005) stated, it seems that a school garden is more suitable to achieve the objectives of curriculum at lower levels of education. Instruction in a school garden can help develop healthy eating habits among students (Morris and Zidenberg-Cherr, 2002; Ratcliffe et al., 2011; Robinson-O'Brien et al., 2009). Research also suggests that an education based on the school garden can improve the quality of students' environmental education (Brynjegard, 2001; Bundschu-Mooney, 2003; Cutter-McKenzie, 2009; Dyment and Reid, 2005; Mayer-Smith et al., 2007), and has a positive effect on the academic achievement of students (Graham et al., 2005; Klemmer et al., 2005; Lieberman and Hoody, 1998; Robinson-O'Brien et al., 2009).

Agricultural areas represent almost a quarter of the Slovenian territory, while arable land represents only about 8%. This position put Slovenia at the very bottom of the European Union. Self-sufficiency in agricultural products is currently very low in Slovenia (e.g. vegetables less than 40%, cereals less than 60%). Students who are currently involved in agricultural education will have to acquire knowledge about agricultural technologies and production, which will in the future provide Slovenia with quality food and a satisfactory level of self-sufficiency. This means that we must give future generations of students the fundamental scientific knowledge that underpins agricultural production.

While gardening programs have become progressively more common, few studies aim to establish the effects of school garden on students (Cutter-Mackenzie, 2009; Mayer-Smith et al., 2007; Ozer, 2007, Ratcliffe et al., 2011). It is also noticeable that most of the school garden research was done on a primary school level in connection with nutrition. Therefore, there is a need for evidence-based studies that extend to the potential effects of the psychosocial and academic development of youth (Ozer, 2007) and to higher levels of education.

We believe that in order to equip students with useful knowledge, changes in education are necessary. There should be more integration of direct experience and practical work in class. Experiential learning has proven to be an efficient interface between theory and practice (Kolbl, 1984). In this model of learning, knowledge is created by transformational experience. It is based on direct experience, which is followed by the formation of abstract concepts and a final check in the new situation. This kind of teaching leads to understanding and thus to a more sustainable knowledge than traditional methods of teaching. Experiential learning and practical experience can help students master subject matter, increase their interest in agriculture and develop scientific reasoning skills (National Research Council, 2006).

Purpose of the study

The future quality of our food and level of self-sufficiency will be strongly influenced by students who are currently involved in agricultural education. During education, they should therefore acquire knowledge and values that are in line with our objectives. Research dealing with the academic effectiveness of school garden programs is scarce, especially at the secondary level of education. Our goal was to establish: (1) whether instruction at the secondary level of education that has experiential learning in a school garden as a focus could yield better knowledge than traditional instruction in a classroom, and (2) how do gender, grade and educational programs in which students are enrolled influence their academic achievements.

MATERIAL AND METHODS

Participants

This study was conducted in the academic year 2012/13 on a sample of 360 secondary school students. In Slovenia, secondary school provides education for students aged 15 to 18. We included students of all four grades of secondary school – there were 118 (32.9%) 15-year-olds, 88 (24.3%) 16-year-olds, 93 (25.8%) 17-year-olds and 61 (17.0%) 18-year-olds. In the sample, there were 184 (51.2%) girls and 176 (48.8%) boys. Students were enrolled into five different educational programs (Table 1). One hundred and eighty-one (50.3%) students took part in experiential lessons in a school garden (experimental group) while 179 students (49.7%) students took part in traditional lessons (the control group).

Knowledge test

For our study, we decided to test the curricular topic, freshwater ecosystems, for its effectiveness for academic achievement. We prepared questions to test students' knowledge. We asked them basic questions concerning (1) knowledge of plants and animals that live in a pond and on its banks; (2) understanding terms that are linked to water ecosystems; (3) understanding measurable characteristics of water ecosystems, and (4) understanding the chemical abiotic characteristics of a water ecosystem. In the test there were items of two cognitive domains – knowing and applying, in the way these two domains are defined in TIMSS 2011 (Kozina et al., 2012). Knowing refers to the students' knowledge base of science facts, information, concepts and tools. Applying is designed to involve the direct application of knowledge and the understanding of science in straightforward situations. In the knowledge test, there were 28 questions regarding knowledge and 29 questions regarding applying. All together it was possible to achieve a maximum of 57 points. Most of the questions (45)

Table 1. Distribution of students across five different educational programs.

		Number of students	
No.	Educational program	Frequency	%
1	Agricultural-Entrepreneurial Technician	48	13.4
2	Food Processing Technician	19	5.3
3	Horticultural Technician	32	8.9
4	Natural Protection Technician	93	25.8
5	Technical High School	168	46.6
	Total	360	100

were open-ended, requiring a short answer. With the remaining 12 questions, students had a choice of two options, i.e. agree or disagree with a given statement.

Procedure

We prepared an instructional unit based on the theory of experiential learning. There were two versions of a unit – one for the traditional instruction in a classroom, and one for the experiential instruction in a school garden. We began the lesson with a short introduction and instruction for students. Students then answered the questions in the knowledge test (pre-test; 15 min). This was followed by a double period (90 min) in which students learnt about the ecology of freshwater ecosystems and their importance. Immediately after the lesson students answered the questions on the knowledge test again (post-test; 15 min). The purpose of these tests was to establish the quality and quantity of knowledge that students gained during the lessons.

Statistical analysis

Data analysis was carried out using the statistical software SPSS (version 21). We performed nonparametric statistics because the data were not distributed normally. A Mann-Whitney U test was used to identify statistically significant differences between the achievement scores of the different genders, and also between students who took part in instruction in a school garden, and those who took part in traditional instruction. A Kruskal-Wallis test was used to establish the differences among five educational programs, and also among four grades. The Jonckheere-Terpstra test was carried out to establish whether there is a significant trend in the data concerning grades and educational programs. A Wilcoxon signed-rank test was used to establish whether there were statistically significant differences between achievement scores in the pre-test and the post-test. The effect size estimate r was calculated.

RESULTS

Knowledge of students before the instruction took place (pre-knowledge)

Results show that there was no difference between the experimental and the control group in their knowledge in the beginning of the experiment. On average, pupils' achievement scores in a pre-test were 19.74 points (SD = 4.01). The control group scored slightly higher (M = 19.82, SD = 6.01) than the experimental group (M = 19.67, SD = 6.37), however, these differences were not statistically significant ($U = 18747.00$, $z = -0.63$, $p = 0.530$) and their effect size was negligible.

We also analyzed in more detail whether there might have been a difference in the pre-knowledge in either of the cognitive domains in which the test was divided, i.e. knowing and applying. We found that there were no significant differences between students in the experimental and the control groups in the cognitive domain knowing ($U = 18357.50$, $z = -0.97$, $p = 0.330$) nor in the cognitive domain apply-

Table 2. Achievement scores of the experimental and the control group.

	Pre-test							
	Experimental Group		Control Group		Difference between experimental and control group (Mann-Whitney *U*)			
Cognitive domain	M	SD	M	SD	*U*	*z*	*p*	*r* (effect size)
Knowing and applying	19.67	6.37	19.82	6.01	18747.00	-0.63	0.530	0.03
Knowing	15.96	3.88	16.36	4.15	18357.50	-0.97	0.330	0.05
Applying	3.71	3.82	3.46	3.27	19387.00	0.06	0.949	0.00

ing ($U = 19387.00$, $z = 0.06$, $p = 0.949$). Both effect sizes were negligible (Table 2).

Influence of gender, grade and educational program on pre-knowledge of students

We wanted to establish whether there were any differences in the knowledge of students before the instruction took place (pre-knowledge) in three aspects: (1) between female and male participants; (2) among different grades, and (3) among different educational programs. Results show that the pre-knowledge of students was not affected by gender since the differences between girls and boys on the pre-test were not significant ($U = 19333.50$, $z = -0.09$, $p = 0.927$, $r = 0.01$).

The pre-knowledge of students was, however, significantly affected by the grade ($H(3) = 22.82$, $p = 0.000$). The Jonckheere-Terpstra test revealed a significant trend in the data: students in higher grades had more knowledge than students in lower grades ($J = 34113.50$, $z = 4.25$, $p = 0.000$, $r = 0.21$).

We also found that the pre-knowledge of students was significantly affected by the educational programs the students were enrolled in ($H(4) = 63.53$, $p = 0.000$). The Jonckheere-Terpstra test revealed a significant trend in the data: scores got higher in the following order of educational programs: agricultural-entrepreneurial technician, natural protection technician, technical high school, food processing technician, and horticultural technician ($J = 29436.00$, $z = 2.13$, $p = 0.033$, $r = 0.12$).

Knowledge of students after the instruction took place (post-knowledge)

In a test that took place after the lessons (post-test), students achieved on average 36.26 points (SD = 9.81), which is 16.52 points better in comparison to the pre-test. Achievement scores in the post-test were significantly higher than those in a pre-test (Wilcoxon signed-rank test; $z = -17.069$, $p = 0.000$, $r = 0{,}61$) (Fig. 1).

Students in the experimental group who took part in an experiential learning in the school garden scored higher (M = 38.13, SD = 10.97) than students in the control group who took part in the traditional lessons (M = 34.21, SD = 7.89). This difference of four points was statistically significant ($U = 15016.50$, $z = -3.92$, $p = 0.000$), though its effect size was small.

Results also show that the experimental group scored significantly higher in both cognitive domains included in the test, i.e. knowing ($U = 14055.00$, $z = -4.79$, $p = 0.000$) and applying ($U = 16115.50$, $z = -2.95$, $p = 0.003$). Both effect sizes were small (Table 3).

Influence of gender, grade, and educational program on the post-knowledge of students

We wanted to establish whether the effectiveness of the lessons was influenced by gender, grade and/or the educational program that students attended. We found that in the post-test the girls on average scored 37.72 points (SD = 10.54), which was three points

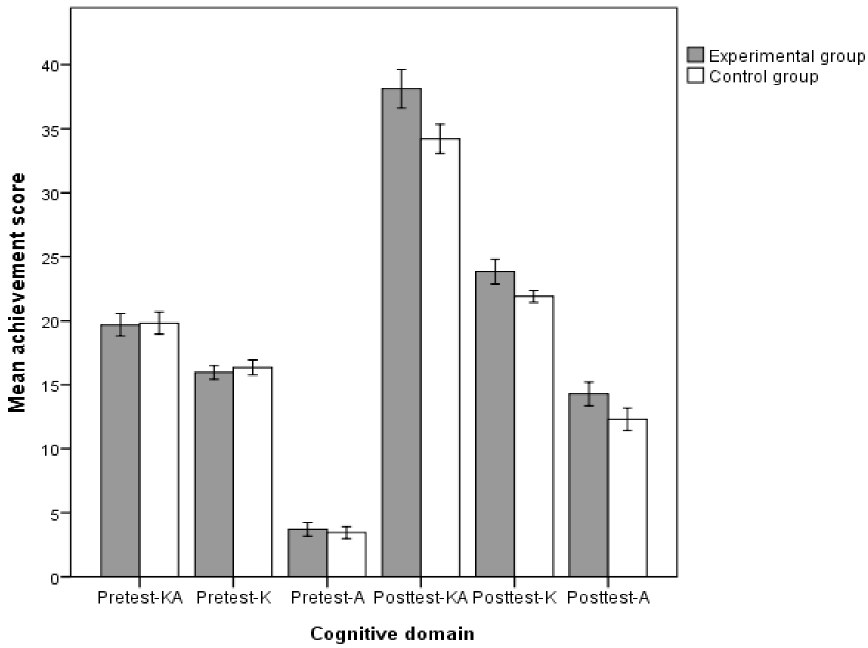

Fig. 1. Mean achievement scores on the knowledge test before the lessons and after the lessons. KA = Knowing and applying, K = Knowing, A = Applying.

Table 3. Statistical significance of differences among students' achievement scores in a post-test (Statistically significant values are shown in bold type).

	Post-test							
	Experimental Group		Control Group		Difference between experimental and control group (Mann-Whitney *U*)			
Cognitive domain	M	SD	M	SD	*U*	*z*	*p*	*r* (effect size)
Knowing and applying	38.13	10.97	34.21	7.89	15016.50	-3.92	0.000	0.20
Knowing	23.84	7.01	21.90	3.13	14055.00	-4.79	0.000	0.24
Applying	14.29	6.77	12.30	6.09	16115.50	-2.95	0.003	0.15

better than the boys (M = 34.62, SD = 8.66). The lessons were therefore significantly more efficient for the girls than they were for the boys ($U = 15956.00$, $z = -3.08$, $p = 0.002$, $r = 0.16$).

As we have already mentioned, there was a significant difference in the pre-knowledge of the students of four different grades. In the post-test after the lessons there were also significant differences in the knowledge among the four grades, $H(3) = 65.86$, $p = 0.000$. The Jonckheere-Terpstra test revealed a significant trend in the data that was similar to the one in a pre-test: students in higher grades had more knowledge than students in lower grades ($J = 38817.00$, $z = 7.98$, $p = 0.000$, $r = 0.40$). Detailed analysis revealed that the fourth grade made more progress (21 points) in their knowledge during the lessons than the first grade (14 points). This suggests that grade was an important factor in predicting the achievement score in the post-test.

The pre-test has already shown that students enrolled in different educational programs have significantly different pre-knowledge. Significant differences in knowledge among the five educational programs were also found in the post-test ($H(4) = 60.74$, $p = 0.000$). The Jonckheere-Terpstra test revealed a significant trend in the data – scores got higher in the following order of programs: agricultural-entrepreneurial technician, natural protection technician, food processing technician, horticultural technician and technical high school ($J = 36411.00$, $z = 7.81$, $p = 0.000$, $r = 0.39$). This is almost the same order as in the pre-test. The one exception was the technical high school program: this one showed an average score in the pre-test, but had the best score in the post-test. Results therefore suggest that program was an important factor in predicting the achievement score in the post-test.

DISCUSSION

The purpose of our study was to establish whether experiential learning in a school garden enables students to gain more knowledge than traditional lessons in a class. The first step was to test students in the control and experimental groups for possible differences in their pre-knowledge of freshwater ecosystems. We found that students in both groups had similar pre-knowledge: we did not find any statistically significant differences in the section of the knowledge test that evaluated the cognitive domain knowing, nor in the section that evaluated the cognitive domain applying (all ps > 0.05; Table 2). This was expected because half of the students from each class were randomly allocated to the control group and half to the experimental group.

Students' pre-knowledge was not influenced by gender; however it was significantly affected by grade and by the educational programs that students were enrolled in. As expected, students in lower grades showed less knowledge than students in higher grades. An unexpected result concerned educational programs. Students enrolled in a technical high school program came to this school with better average achievements in the previous educational level (elementary school) than students in any other program; yet they showed medium pre-knowledge about fresh water ecosystems. We could not find any plausible explanation for this. Scores were distributed in the following order of educational programs: agricultural-entrepreneurial technician, natural protection technician, technical high school, food processing technician and horticultural technician.

The next step was to compare the achievements of students after the lessons (post-knowledge) (Table 3). Students' achievement scores on the test immediately after the lesson were 36.26 points (SD = 9.81) compared to their scores before the lessons when they were 19.74 points (SD = 4.01). This gain of 16.52 points during the lessons was significant and shows that the lessons were effective in achieving the set learning objective.

We found that students who took part in experiential instruction in the school garden gained significantly more knowledge than students who took part in a traditional lesson in a class ($p = 0.000$). This is in accordance with the generally excepted opinion supported by research as well (Kolbl, 1984). Experiential instruction in the school garden brought about higher achievement scores in the cognitive domain knowing ($p = 0.000$), which refers to a student's knowledge base of science facts, information, concepts and tools. Achievement scores were also higher in the cognitive domain applying ($p = 0.003$), which is designed to involve the direct application of knowledge and understanding of science in straightforward situations (Kozina et al., 2012). Although experiential instruction in the school garden significantly improved the achievements of the students, the effect size of improvement was small (Table 3). In the cognitive domain knowing the effect size was 0.24, while in the cognitive domain applying it was only 0.15. We can therefore conclude that experiential instruction in the school garden had greater effect on knowledge of the facts about freshwater ecosystems and lesser effect on a deeper understanding of this topic. We assume the effect would be greater if students were better mentally activated. Mental activity is a necessary condition that makes experiential learning more effective in an academic sense than other methods of teaching/learning (Gallagher, 2007).

Therefore, we can deduce that instruction was not effective enough in some areas. It seems that it mainly focused on gaining new facts that are readily available in the school garden, such as recognizing plants and animals. Although the school garden provided teachers with adequate surroundings for instruction about a freshwater ecosystem and its biotic and abiotic factors, it seems that the instruction did not extend further. Due to limited time, students and teachers did not discuss and reflect on the meaning of topic taught. Therefore, students did not develop scientific reasoning and therefore scored better in the cognitive domain applying in the post-test. As the National Research Council (2006) stated, when teachers view practical experiences as isolated events that do not contribute to a mastery of topics and if science class time is short, practical experiences may be limited.

One solution could be the so-called integrated instructional unit, which is a term proposed by the National Research Council (2006) to describe the sequence of instruction that connects practical experiences with other types of learning activities, including lectures, reading and discussion. The studies conducted to date indicate that integrated instructional units show greater effectiveness in improving mastery of subject matter, developing scientific reasoning and cultivating interest in the subject matter.

Teachers play a critical role in leading effective experiential instruction in a school garden. Teachers of science subjects are not used to teaching in a school garden. Such instruction requires special preparation. Rigid school schedules may discourage teachers from making more use of a school garden. Such teaching is also to some extent weather dependant. Research also shows that teachers lack confidence about their knowledge of nature. A common answer is that they could be confronted with questions they will not be able to answer. Since experiential instruction in a school garden is not common, there is a problem with the students as well. Only 12% students perceive a school garden as an area for educational purposes (Pogačnik et al., 2013). They are not used to such instruction, and easily get distracted by objects and events in the surroundings that have no connection to instruction. Students have to learn how to perform experiential learning in a school garden for it to be effective, just as they have to learn how to handle a microscope or laboratory equipment. Students generally perceive practical work as more interesting; however, this does not necessarily in itself result in better knowledge.

Students' post-knowledge was influenced by gender, grade and the educational program students were enrolled in. Girls showed significantly better post-knowledge than boys, which suggests that they were more mentally active during the instruction. Students in higher grades showed more knowledge than those in lower grades. This is probably because a greater knowledge base itself helps to increase knowledge. Students' scores got higher in the following order of educational programs: agricultural-entrepreneurial technician, natural protection technician, food processing technician, horticultural technician and technical high school. The students in four of the programs kept the same positions as in the pre-test. Only students in the technical high school program switched from the medium to the highest position. This means that instruction was more efficient for them than for the other four programs.

CONCLUSIONS

The experiential learning in a school garden that we employed in our study proved to be more effective in teaching students about freshwater ecosystems than traditional lessons in a classroom. This survey showed the effectiveness of instruction in a real school situation. It also demonstrated the importance of the aptitude of teachers and students to carry out this kind of instruction. Improving science teachers' capacity to lead experiences in the school garden effectively is critical to advancing the educational objectives of these experiences. Pre-service teachers should be better prepared for experiential instruction in a school garden. They should receive the pedagogical and science content knowledge required by carrying out such teaching strategies as part of their pre-service education.

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