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Vermicomposting in Mexican Secondary Biology Classrooms: Effects on Learning Outcomes and Student's Motivation

M. Teresa Guerra-Ramos[1], Rocío G. Balderas-Robledo[2], Yei J. Rentería-Guzman[3], José B. García-Horta[4]

[1, 2, 3] Centro de Investigación y de Estudios Avanzados del IPN, Unidad Monterrey
[4]Facultad de Trabajo Social, Universidad Autónoma de Nuevo León
(México)
[1] tguerra@cinvestav.mx, [2]rbalderas@cinvestav.mx, [3]yrenteria@cinvestav.mx,
[4]jose.garciaht@uanl.edu.mx

Abstract

The purpose of this study is to evaluate the effects of a classroom long term project centred on experiences related to composting with earthworms (vermicomposting) in secondary Biology classrooms. The project aimed to systematically incorporate practical activities with living beings as situated teaching-learning scenarios in the context of predominant lecturing type teaching practices. Participants were 5 Biology teachers working in two state schools and 333 students aged 12-13 in a suburban area of Monterrey, a northern city of Mexico. Several small groups of students within each class took care of a composting bin with earthworms during a school year. This task involved feeding and dampening earthworms in the composting bin, as well as measuring and recording temperature and humidity regularly. Teachers and students engaged in activities related to nutrition, respiration, reproduction of earthworms and their role in environmental processes. Students' productions were collected in selected sessions. At the beginning and at the end of the project, students responded to a questionnaire that explored biological knowledge, some process skills (understanding, interpretation y application of information) and environmental awareness attitudes. Students also produced free texts about what they liked and disliked in the project. These texts were qualitative analyzed. The comparison of initial and final questionnaire results suggested that students improved significantly in their biological knowledge about earthworms and composting, their ability to understand, interpret and apply related information. Students' texts reflected evidence of high motivation to participate in vermicomposting activities, attitudes of responsibility and collaboration, and the developed of increasing interests in living beings and environmental issues.

1. Introduction

The problem of how to provide formative and significant science education to young learners in coherence with a wide and demanding curriculum is still a great challenge to teachers around the world. In Mexico, science education has been reformulated in official documents and textbooks within the framework of several curricular reforms. The stated aim of the official curriculum is to provide a background that promotes the development of scientific competences in which knowledge; process skills and attitudes are integrated [1]. Despite the well-intentioned educational discourse there is still a lack of resources and concrete strategies that support teaching practice. We report here a study to evaluate a project developed to consistently incorporate activities with living beings as situated teaching-learning scenarios. The project is centred in series of activities related to the transformation of organic waste in a vermicomposting system or composting bin with earthworms. The idea to develop a project of this nature arose from the fact that biological curriculum content is usually taught without making reference to concrete living beings and without the systematic incorporation of practical activities. Consequently, the aim of this study is to evaluate the learning effects of a long-term project centred on experiences related to composting in secondary Biology classrooms.

2. Theoretical perspective and previous research

The project *Worms to school* entails a situated perspective of teaching and learning, in which knowledge is not independent of the context in which it is used [2, 3, 4.]. This perspective arose in the 1980s in contraposition to the then dominant view which considered that knowing occurred essentially in solitary: thinking was considered to be detached from perception and action, and the

context was of secondary, if relevant at all. The situated knowledge perspective flourished initially in the study of mathematical knowledge applied in real life settings [2] and in the investigation of teaching and learning of vocabulary and reading skills [5].

Composting bins and earthworms have been used with educational aims in different educational settings with diverse objectives and approaches [6,7,8,9]. Such experiences seem to have an enormous potential to provide concrete contexts that promote the intellectual involvement of students and teachers. They have been used to promote argumentation on biological processes and the environmental benefits of composting in reducing organic waste end the re-integration of nutrients to soil, also to promote elaboration of hypothesis and the design of experiments. There are few reported secondary science education experiences using vermicomposting systems; such experiences have rarely included systematic collection of empirical evidence about their educational effects. Although vermicomposting systems, commonly called worm bins, have been used for educational purposes for decades, there is still little evidence of their effects in teaching and learning of related biological curriculum contents. Despite their ease of maintenance and affordability, such systems, that allow keeping a living being in the science classroom, remain marginal as valuable teaching resources in Mexican science education.

2. Methods and sample

This mixed-methods investigation was intended as an initial study with a purposeful sample. Five teachers, assigned to ten groups, consisting of 333 students aged 12-13, were invited to participate. Their participation in a long-term composting related project occurred in the context of the subject Science I (emphasis in Biology). Teachers were experienced Biology teachers (three females, two males) working in public secondary schools located in an urban-marginal area of Apodaca, Nuevo Leon (Mexico). We provided a composting bin and tools for each students group. Teacher received a kit of hydro-thermometers and printed description of the project and activities. Teachers volunteered to implement the activities designed by us in order to improve learning outcomes and students' motivation. The project was called "Worms at school" and included two components:

1) Collaborative open-ended activities. Students working in small groups, and coached by teachers, were responsible of handling a composting bin with red wigglers (Eisenia foetida) during a school year (ten calendar months). This involved finding out the right type and amount of food and water to maintain alive the worms in the composting bin. Additionally, students had to use a hydro-thermometer in order to measure and record temperature and humidity once a week. Students could decide the best ways to make decisions, organize duties and solve problems.
2) Structured classroom activities. Teachers and students engaged in a series of activities to learn about biological characteristics of worms: aspects of their nutrition, respiration, reproduction and their role in the biological processes related to the transformation of organic waste into nutrient-rich soil called compost. These activities were conducted in a monthly session lasting 80 minutes approximately.

Our main sources of data to estimate the educational effects of the project were:.

- Students' responses to a questionnaire exploring biological knowledge about earthworms, related process skills (understanding, interpretation y application of information) and environmental awareness attitudes (towards generation of garbage and living beings), applied at the beginning and at the end of the project.
- Students' records of temperature and humidity
- Students' productions in selected classroom activities (i.e. drawings, charts, figures, etc.)

Since a combination of qualitative and quantitative data was collected, information was processed accordingly. Responses to the questionnaires were entered in a database to be processed with SPSS to obtain frequencies, means, overall scores and Student's T to compare initial and final scores.

4. Outcomes

Data collection was completed at the end of the school year, in July 2015. In the whole sample (333 students) the mean of initial score (percentage of right answers) was 45.8 and the mean of final scores was 63.0 ($t= -20.65$, $p<0.05$). Table 1 offers means of initial and final scores for each of 10 students groups, each school and the whole sample. We designate groups with numbers and teachers with letters. In all cases, the final score increased and the difference among initial and final

score had statistical significance. The increase among initial and final scores ranged from 9.4% to 24.5%. Group 10 obtained the lowest increase and group 4 got the highest increase.

Table 1. Initial and final scores obtained in the questionnaire by group/teacher, school and whole sample (percentages of right answers)

		MEAN			
	GROUP/TEACHER	INITIAL SCORE	FINAL SCORE	INCREASE	t
SCHOOL A	1/A (n=36)	43.5%	65.6%	22.1	-9.152*
	2/A (n=40)	41.6%	62.4%	20.8	-10.511*
	3/B (n=33)	44.2%	64.6%	20.4	-8.077*
	4/B (n=35)	37.7%	62.2%	24.5	-8.819*
	5/C (n=40)	48.4%	64.3%	15.9	-6.878*
	n=184	43.2%	63.8%	20.6	-19.11*
SCHOOL B	6/D (n=33)	54.6%	71.6%	17.0	-6.977*
	7/D (n=29)	48.7%	63.0%	14.3	-4.481*
	8/D (n=33)	49.0%	58.8%	9.8	-4.269*
	9/E (n=28)	43.4%	57.1%	13.7	-4.866*
	10/E (n=26)	48.9%	58.3%	9.4	-3.343*
	n=149	49.1%	62.1%	13.0	-10.659*
TOTAL	N=333	45.8%	63.0%	17.2	-20.650

* Significance p<0.05

Table 2 presents the results obtained in terms of increase in the percentage of right answers in each section of the questionnaire, sections exploring knowledge, process skills and attitudes. The data suggest that students improved significantly in their biological knowledge about earthworms and composting, their ability to understand, interpret and apply related information. According with data from questionnaire, attitudes towards generation of garbage and living beings also increased although not significantly since attitudes were good in this respect from the beginning.

Table 2. Initial and final scores obtained in each section of the questionnaire considering the whole sample (percentages of right answers)

	INITIAL SCORE	FINAL SCORE	INCREASE	t
Section 1. Knowledge about earthworms and composting	39.2%	61.9%	22.7	-22.174*
Section 2 . Understanding of temperature	70.5%	87.5%	17	-10.757*
Section 3. Interpretation of information	51.4%	63.8%	12.4	-5.992*
Section 4. Application of information	46.0%	75.0%	29	-11.639*
Section 5. Explanation	60.0%	81.0%	21	-3.936*
Section 6. Estimation	6.0%	12.5%	6.5	-4.473*
Section 7. Attitudes towards generation of garbage	28.0%	44.0%	16	-4.857*
Section 8. Attitudes towards living beings	64.0%	65.5%	1.5	-0.422
Total score	45.8%	63.0%	17.2	-20.650*

* Significance p<0.05

Students' records of temperature and humidity suggested that at the beginning of the project students did not use confidently the hydro-thermometer, confused data and made irregular and mechanical records without interpretation. These tendencies changed by the fifth month of consistently keeping records. By the end of the Project, students tended to make regular weekly records, write down interpretations that were more accurate, so to speak, and record other incidences related to other aspects of worm biological features. 11 out of 54 students small groups did not managed to keep regular records or relate data to find out the best conditions in terms of temperature and humidity for earthworms.

Students' productions in classroom activities indicated overall tendencies as a progressive gain in the use of data to elaborate and interpret graphs of temperature and humidity. We also identified texts elaborated by students in which initial feelings of repulsion towards earthworms were gradually left behind. Students also expressed a sense of responsibility connected to the experience of keeping earthworms alive and working collaboratively in small groups. The analysis of data suggests that after the implementation of the project students improved their conceptual knowledge, make better interpretation of graphs and tables, and display positive attitudes, increased responsibility and interest in Biology themes.

3. Conclusions and implications

Teaching Biology at secondary school should include significant contexts and engaging situated activities. It is ironic that the learning about living beings frequently occurs, in the Mexican context, without the opportunity to experience activities with living creatures. The project *Worms to school* provides the setting to articulate a systematic inclusion of activities with living beings in the classroom and the study of curriculum contents. Themes as biodiversity, nutrition, respiration, reproduction and environment processes could be studied in a significant context.

Our initial evaluation of the learning effects of the project is serving us as a starting point for further research, development and improvement of teaching resources for secondary science education. Although most of the results indicate positive effects on learning biology concepts, process skills and attitudinal contents, we recognize that the uptake of innovative strategies is not simple or straightforward. Activities with living beings in the secondary science classroom imply temporal and material limitations. As well as convincing teachers, students and other educational actors (head teachers, parents) to be engaged in an effort to avoid mechanical and de-contextualized science teaching and learning.

In future research work we aim to refine our methodology to focus on the development of scientific thinking skills and the potential of long-term projects as a mean to reinforce teacher professional development.

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