# Formal Citizen Science in the 5th Grade: Ineffective but Informative and Highly Influential

**Adiv Gal**
**Kibbutzim College of Education Technology and the Arts**

*The present study examines the effectiveness of integrating 5th grade students as part of citizen science aimed at preserving the Lesser Kestrel. The study examined the quality of the database collected by the students. During the project, students used mobile phones and the Survey123 app for locating nesting boxes for the Lesser Kestrel. The application provides a simple data collection solutions using online forms, enabling the students to create, share, and analyze surveys with a geographic location component. The study used a mixed-method approach to examine the efficiency of data collection by 5th and to examine student perceptions of the survey's outcome. The results indicate that the database was not effective due to lack of sufficient reliable quality data. However, even the partial data collected raise concerns for the future of the Lesser Kestrel population in the area. In addition, the study also revealed that the survey (a) contributed to positive learning experiences, (b) increased motivation and (c) strengthened the social relationship among the students.*

*Keywords: Lesser Kestrel, Bird Survey, Formal Citizen Science, GIS*

## INTRODUCTION

Citizen science, a pioneering form of crowd-sourcing, is the combination of scientific researchers working with people who do not come from the world of scientific research or from the scientific community and have no practical research experience (He and Wiggins, 2017; Hulbert 2016; Tulloch et al., 2013). Some argue that citizen science emerged as part of the development of the environmental movement in the 1960s and 1970s (Cunha et al. 2017). Despite reservations regarding the use of citizen science which focus on the quality and reliability of the data collected by unpracticed citizens (Cunha et al. 2017), and duplication of the data (Callaghan et al. 2018), there is great appreciation for the use of citizen science as a research tool (i.e. Paige et al. 2015).

The use of citizen science has expanded over the years (Callaghan et al. 2017; McKinley et al. 2017; Tulloch et al. 2013). The integration of people as part of citizen science changes based on time, space, research goals, methods of data collection and age of participants (Crall et al. 2017). A wide range of articles describes the contribution of participation in the process of citizen science to both researchers and citizens (Crall et al. 2017; McKinley et al. 2017).

The contribution to both science and researchers in an era when the planet is in trouble (Paige et al., 2015) cannot in many cases be quantified. Due to the impact of humanity on biodiversity and the rapid changes taking place in our world (Marczak and Sorokowski, 2018), there is a growing demand for extensive scientific information. The data may help in examining the effect of people on biological

diversity as well as animal and plant populations (Parsons et al. 2018). This extensive information, used as a basis for monitoring and management of action plans regarding animal populations, has become significant in terms of the effect of humans on these populations (Parsons et al., 2018), especially populations of endangered species that have settled in a developing urban environment. Therefore, citizen science may supply large databases collected over time over a wider range than what scientists can achieve on their own (McKinley et al. 2017; Parsons et al. 2018). Technological development also helps to expand the circles of scientific action through citizen science. Technology expands the survey's boundaries and the extent of information that can be collected by citizens contributing to scientific research (He and Wiggins 2017). These citizen scientific databases may be useful if examined through the lens of resource investment, particularly time and money, which are often limited (Tulloch et al. 2013).

The lay participants in citizen science are most often adults with sufficient income (He and Wiggins 2017). Among the benefits of citizen science is the strengthening of the connection between citizens and science (Pandya, 2012), especially in an era when the relationships amongst the sciences are crucial (Paige et al. 2015). The benefits include increased awareness of science and the environment (Brossard et al. 2005), contributing to the body of scientific and environmental literature (Cunha et al. 2017), and adoption of scientific thinking (Glaze 2018). Participants in citizen science have a better understanding of key issues, especially in their immediate surroundings, and therefore have a greater ability to influence decision-makers (Cunha et al. 2017), thus becoming activists (Parsons et al. 2018).

One branch of citizen science is collecting information about birds. This type of citizen science has been recognized for decades (Callaghan et al. 2018). People who have continued to specialize in ornithology, not for profit, were nicknamed "amateurs" (Greenwood 2007). This ornithological information was collected in order to learn about trends and changes in size and distribution of different bird populations (Wei et al. 2016). It is apparent that amateurs in the field of bird watching can collect and provide qualitative information, which will enable understanding of changes in the distribution and wealth of different bird species (Callaghan et al. 2018).

The same is true in Israel. Ornithological citizen science has been operating in Israel for decades. Amongst the main projects that monitor birds in Israel using citizen science is the Soaring Birds Project (Leshem and Yom-Tov 2008) established in the late 1970s and managed by the Society for the Protection of Nature in Israel (SPNI), the Waterfowl Survey conducted by the Nature and Parks Authority, and a bird survey conducted in backyards by the Center for the Cultivation of Wild Birds. All of these projects involve adult citizens from Israel and overseas, who contribute to the collection of information about the various bird groups in Israel.

One of the citizen science projects conducted by the SPNI is the Lesser Kestrel project. The Lesser Kestrel is a small raptor which has been studied in Israel for nearly two decades. There are a number of scientific publications on the topic, dealing mainly with the two populations of Alona and Jerusalem (i.e. Bobek et al. 2018; Gal et al, 2019). Both of them were considered the largest in the country until the end of the 1990s, including nearly 200 nesting pairs in both areas together (Liven-Schulman et al. 2004). However, in the last 20 years there has been a drastic decline in the size of these populations. The population in Jerusalem has become almost completely extinct, while the population in Alona has suffered a dramatic decline (Perlman 2013).

Citizen science also has a place in the education system, mostly in its informal sector (He and Wiggins 2017), and to a lesser degree in the formal education system (Lewandowski and Specht 2015; Tulloch et al. 2013). The inclusion of citizen science in the education system enables students to be more involved in the learning process, in addition to increasing their involvement in and caring for the subjects studied (Cunha et al., 2017). Citizen science increases the potential of student engagement through active and inquiry-based learning (Mitchell et al. 2017). Students in a citizen science monitoring project have demonstrated significantly higher levels of biological and ecological knowledge, as well as awareness of human behavior impacts on the environment (Branchini et al. 2015). Last but not least, citizen science increases motivation for learning due to student participation (Tulloch et al. 2013). The teachers who lead citizen science in schools also benefit as partners in the activity. Citizen science supports professional

scientific development and personal empowerment. Furthermore, the teachers may develop good relationships with their students following continuous communication with them (Paige et al. 2015).

Along with the broad benefits for teachers and students, it should be noted that in quite a few cases citizen science in schools differs from the accepted definition of that based on direct contact between researchers and participants. In many schools, the teachers act as a bridge between students and researchers, eliminating the direct connection between them. Even if there is a connection between students and researchers, the nature of the relationship is unclear (Paige et al. 2015). In addition, the examination of citizen science activity in the school is most often carried out through the teachers' eyes rather than those of the students (He and Wiggins, 2017).

In Alona school, which belongs to the formal education system, part of the citizen science project is carried out by 5th grade students as part of their regular curriculum. The students contribute to citizen science by conducting surveys in their region to help protect the Lesser Kestrel. This is an example of the use of citizen science bringing together 5th grade students and researchers from the SPNI to collect vital information regarding sites where nest boxes can be placed. Therefore, the aim of this study was to examine the effectiveness of data collected by 5th grade students as part of their formal environmental education program, as well as their perceptions regarding their social relationship following their participation in citizen science. I asked the following questions: What is the quality of data collected by 5th graders in the framework of citizen science designed to help preserve the Lesser Kestrel? What is the contribution of their experiential learning in citizen science to certain aspects of their education?

## METHODS

### Study Region

In the Alona Regional Council (32 ° 34'N 35 ° 01'E, 100m asl), the Lesser Kestrel nest in three settlements: Aviel, Amikam and Givat Nili. The area is considered a rural environment and is characterized by two types of nests: those beneath the roof tiles or asbestos roofs and artificial nest boxes built by the 5th grade students of Alona School. All the children from six to 12 years old in those three settlements attend one elementary school in Amikam. In this school, the Lesser Kestrel nest under the roof tiles or in nest boxes.

### Research Context

From 1996 to 2017, 5th graders at the Alona School in northern of Israel have been conducting surveys in order to locate houses suitable for the positioning of nest boxes**,** as part of an environmental program that helps the endangered species of the Lesser Kestrel. The students conducted a week-long after-school survey, going from house to house in their own respective residential areas. After conducting the survey, the students examined the characteristics of all the houses they had visited and held a democratic class discussion with the goal of deciding which ten families would receive a nesting box. For the first 22 years the survey was conducted manually with printed maps. In 2018, a new application was developed for the students (see below) using GIS technology, aimed at replacing the use of printed maps.

### App

The students used the Survey123 application to perform the nesting survey for the Lesser Kestrel, which is part of the ERSI ArcGIS Online environment. Survey123 provides a simple and intuitive solution for collecting data using online forms. It enables the creation, sharing, and analysis of surveys with a geographic location component, filling in the answers on mobile phones/tablets directly from the field, and associating the survey answers with an image of a geographical location on the map using the mobile phones' built-in GPS program. Each form sent from the phone is added as a point on one geographic information layer containing all the survey and answer points sent by the children. The information layer containing the answers from the survey is presented on a map which presents an up-to-date, real-time snapshot of the survey results accompanied by diagrams. Thus, while doing the survey the

students can see in real time where the rest of their classmates are located, in which homes the survey had been conducted, and the state of the information base they are filling in.

**The Survey**

The 2018 survey included 560 households. It was conducted after school hours by 55 5th grade students during a week-long period. Each child devoted approximately six hours to this task, so that all students together invested approximately 330 observation hours. In total, the three settlements in which the children operated were divided into nine sub-regions, each covered by a group of two-three students. The study used an unstructured survey (Callaghan et al. 2018), characterized by the fact that collection of information is not necessarily formal or specific. The students had to go through all the houses in their sub-region and fill out a form with 16 fields: settlement name, roof shape, roof type, number of nesting boxes, nesting box type, cat presence, dog presence, owners' wish for a box, Lesser Kestrel nesting on the roof, nesting in previous year, phone number, last name, first name, surveyors' names.

**Data Sources and Analysis**

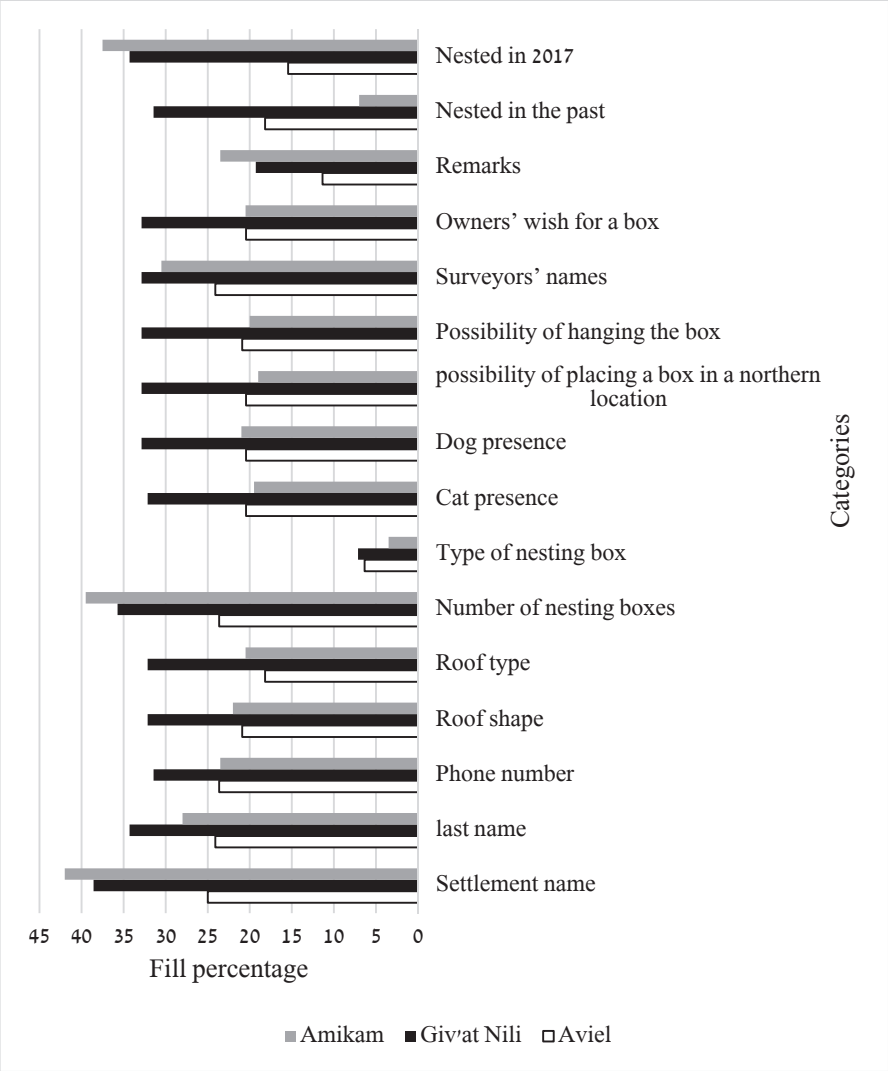
The study was carried out using a mixed-method approach, including three sources of information. The quantitative section was based on a descriptive analysis of the data base collected by the students during the survey. The qualitative section included a questionnaire of six open questions. The third data-collection tool was six focus groups of approximately nine students each, both boys and girls. The duration of the discussion in each focus group was approximately 45 minutes. The sessions were recorded and transcribed. The information collected was analyzed using an interpretive qualitative method. The qualitative analysis of the findings was done using first-cycle-coding, a coding process of data analysis that splits the data into coded segments, and second-cycle-coding using axial coding, which enabled the creation of categories emerging from the interpretive analysis of the data (Saldaña, 2009).

**RESULTS**

**Quantitative Analysis - Database Quality**

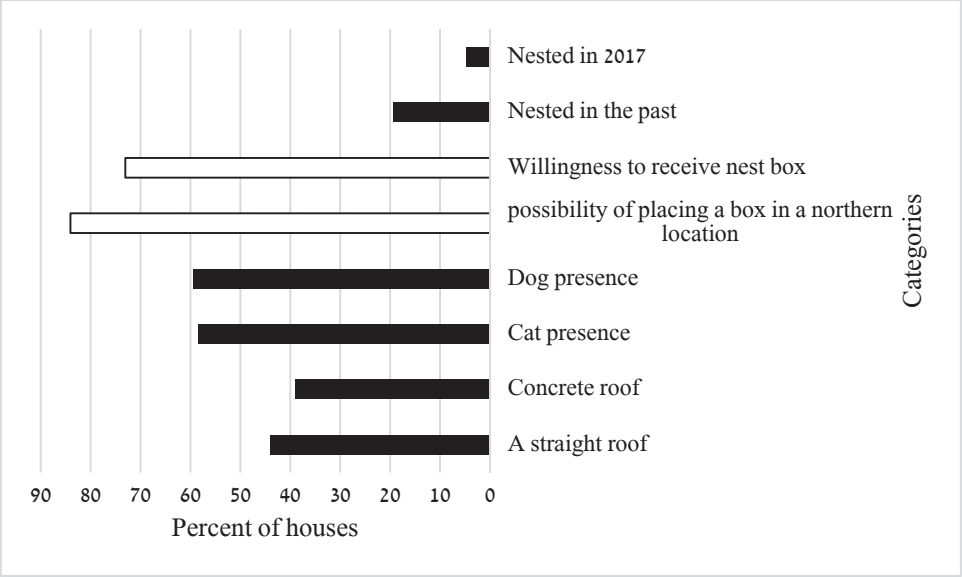
The database that the students were to fill during the survey in 2018 should have included 8,960 cells, but only 2,576 cells (about 28.7%) were filled in. The information collected by the students was obtained from 228 houses, which constitute approximately 40.7% of all existing homes in the three settlements. However, of the 228 homes which students entered, only 193 were registered (84.6%). In Aviel, the percentage of houses surveyed was 25.0%, in Givat Nili approximately 38.6%, and in Amikam approximately 42%. There is great variation in the percentage of missing information in each field of the survey form (Fig. 1).

**FIGURE 1**
**DISTRIBUTION OF THE PERCENTAGE OF MISSING INFORMATION IN EACH OF THE FIELDS OF THE ROOF SURVEY FORM ACCORDING TO THE DIFFERENT LOCALITIES**




The Kruskal-Wallis test showed that there was a statistically significant difference (P = 0.001) between the percentage of filling in of the different fields in the different settlements. Only the data that affected the size of the population of the Lesser Kestrel in Alona or could contribute to understanding trends in the size of the Lesser Kestrel population was analyzed (Fig. 2). This data included: roof shape, roof type, cat presence, dog presence, option to place a box in a northern position, owners' wish for a nest box, nested in the past and nested in 2017.

**FIGURE 2**
**PERCENTAGE OF HOUSES WITH ECOLOGICAL ASPECTS THAT INFLUENCE THE LESSER KESTREL (BLACK NEGATIVE AND WHITE POSITIVE)**




In Fig. 2 we can see that there is a willingness of more than 70% of the residents to hang a nesting box in their home, and in more than 80% of the houses the nesting box can be placed in a northern location. However, there are many factors, for instance the presence of cats and/or dogs in almost 60% of the homes, which pose a danger to falcons. In almost 40% of the houses the roof structure does not allow for the hanging of nesting boxes. Given the dangers to Kestrels from cats and dogs, and the lack of suitable roof structures, the number of residents who have seen nesting in their homes is relatively low (under 20%). Moreover, from the data collected by the children, less than 20% of the residents in the Alona region had experienced Lesser Kestrel nesting in the past, and fewer than 5% reported nesting in the previous year. Accordingly, there are only 10 nests in all the 228 homes visited by students, and no more than 27 nests in the entire Alona region.

**Qualitative Analysis**

Three main issues can be learned from the qualitative analysis of the questionnaire and focus groups. (a) The contribution of the survey as part of citizen science to the students' learning experience; (b) social issues; (c) the importance of integration of technology which enhances student motivation in learning, creating a positive learning experience.

*Students' Learning Experience*

The students expressed a variety of positive arguments related to conducting the survey as part of the learning process in their school environmental program. First, students dealt with diversity in the learning process. One of the students said "It's a different type of learning." Another student added "It takes us out of the school routine". According to the students, the survey enabled them to have a different learning experience. In addition, the students claimed it had improved the learning experience, as one student put it "Making the learning experience more fun and thus more children will participate", or as another student pointed out "Easier and more fun." The students' positive experience during the survey seemed to be very meaningful to them. An interesting conclusion is demonstrated in the following quote "It's very challenging and great fun to learn because it's something we do not do at school and it's also very different." The idea that the survey was perceived by the student as a break in the routine was surprising in light of the considerable investment being made in the school to combine a variety of pedagogies and

alternative assessments. In conclusion, the students expressed many positive arguments that support the survey, constituting an integral part of their active learning involvement in the program.

*The Social Aspect*

This aspect of conducting the after-school survey received great attention in the students' responses. Some of the students referred to a meeting with other students. For example, one of the students claimed "…and we could meet new friends", and another student said "…talk to each other a bit and get to know each other". The students' comments indicated that the survey had helped them get to know each other better. They emphasized that not only did they get to know their classmates better, but also "It helped to bring my class together", and "This is a bit like walking along the street together", or "The group work helped us become a group." The development of the social skills of teamwork, which requires consideration of the other and division of roles, emerged quite a bit, as this student pointed out "We helped because we were in groups, we divided the work", or another student "We had to divide the roles among us." An interesting aspect noted by some of the students was the understanding that cooperation requires not only role sharing but also help in times of crisis, as one student pointed out "To encourage each other not to be upset." In fact, the students were introduced to the complexity of teamwork. The development of behavioral flexibility due to teamwork was also evident in the following statement "We learned how to be flexible because there were also problems with other people in the group and I had to give in." In summary, the students' statements indicate that the social aspect of conducting the survey as part of the citizen science in which they had participated had a great influence on their understanding of the elements of teamwork.

*The Technology Aspect*

The use of mobile phones, including the new application and the use of GIS, did not surprise the children. Although they did not know the application specifically, it seemed that the use of a new app is not alien to them. Several students said "Because we know all the technologies really well"; "Children understand more about a technological device than pen and paper", and "Because we are part of a technological generation." From these answers, it was evident that they were self-confident and felt comfortable regarding their acquaintance with tools from the technological world and the opportunity of operating a new application. In conclusion, it can be said that the students felt comfortable using the mobile phone and the new app and did not feel any discomfort with this aspect of the program. Theoretical practice of the application during school hours, without practical experience, did not cause students to feel uncomfortable about running the application during the afternoon survey.

Students were also able to point out all the disadvantages of using technology that arose from problems. "Because if there is no Internet it gets stuck", or "There are tasks that need the Internet and we do not always have it." Another problem which the students encountered was the lack of data retention, as a number of the students noted "In my group, three houses were deleted and we started again and this delayed us", or "... so we continued with the problem and then it was not sent and it just creates unpleasantness because you really tried and then at the end it was not sent at all. " An additional problem was lack of technical support during the afternoon survey "Because I had a problem with the application and the teachers could not always be available", or "Because something did not work for us in the application and it was hard to deal with it alone." A fourth problem was frustration as a result of the use of the mobile phone and the new application, as one student said "But out of a lot of houses where we did the survey, we saw only two houses on the map and it wasted a lot of time." Another problem raised by the students was the fear that the mobile phone battery short shelf life will not allow them to complete the survey "But the phone can run out of battery", or "But there are also faults as the charging ends." It is apparent that the students experienced a variety of technical problems as a result of the use of advanced technology based on mobile phones and the new application.

## DISCUSSION

Alona School provides a model that can be implemented in order to examine the advantages and disadvantages of using citizen science in an elementary school where there is a direct connection between researchers and students. All the characteristics of citizen science in Alona School described in this article exemplify the innovation and importance of research through the eyes of 5th graders participating in citizen science and in direct contact with researchers.

In this study, the data collected by 5th grade students as part of their formal environmental education program, was indeed only partially successful. As a result, we might assume that this formal citizen science program had failed. The amount of missing data is extremely high and there are noted statistical differences in the collected information in the various parameters. Nevertheless, similarly to other citizen science programs (Callaghan et al. 2018), the partial data collected is vital in two important areas - nature conservation and several educational aspects.

*Nature Conservation*

The survey, compiled in an effort to find suitable homes for nesting boxes for the Lesser Kestrel, has implications for a recent IUCN decision, at least in Israel. The IUCN recently removed the Lesser Kestrel from the vulnerable species list, defining it as of least concern (IUCN 2018). This definition by the IUCN includes all the falcon populations in the Paleartic region, due to the refinement of data obtained from all the species' distribution areas. At the same time, in the Alona area, which had housed in the past one of the largest colonies of the Lesser Kestrel in Israel (Liven-Schulman et al. 2004), the trend is diametrically opposed. The nesting sites in wooden roofs are diminishing, and the number of houses with potential predators, such as cats or dogs, is increasing. Although there is a possibility of positioning the nest boxes in quite a number of houses, it seems that the Lesser Kestrel population's ability to thrive is poor due to these factors. From the incomplete student survey we can learn that the number of nests is extremely low compared with that of the Lesser Kestrel population observed some 20 years earlier (Liven-Schulman et al. 2004). Thus, the partial data collected by the 5th graders is imperative for our understanding of the population decline of the Lesser Kestrel in the Alona area, as well as its uncertain future. Another question posed is the percentage of residents willing to receive nesting boxes. The figure collected by the students exceeded 70%. This figure is seemingly lower than expected, given the fact that the population in the Alona Regional Council has been familiar with this citizen science program since 1996. However, in light of the demographic changes that have taken place in recent years in the composition of the settlement population to which non-native residents have emigrated, we can explain why only 70% of the residents are interested in nesting boxes. The newcomers are perhaps unfamiliar with this citizen science program. It is clear that the demographic change can also have a detrimental effect on the falcon population, as a result of a decrease in the number of people familiar with the project and the resulting decrease in the number of people willing to allow nesting boxes to be placed on their roofs.

*Educational Aspects*

Regarding the study's educational aspects, we can see that citizen science was very meaningful for the 5th grade students. These results are similar to other studies which found that when an environmental program focuses on a meaningful subject, learning is more meaningful (Gruenewald 2003). In this case, the focus on the Lesser Kestrel, which is the students' 'neighbor', has indeed made learning very meaningful for them. The students provided special, valuable, critical and mature perspectives on the advantages and disadvantages of participating in a citizen science program. Regarding the social aspects, it may not be surprising that there is no mention in the literature of the social aspects of citizen science as presented in this study. In most of relevant studies the involvement of people with no scientific education in citizen science was done differently than in the present study (Paige et al. 2015). In our case, the survey as part of citizen science was conducted in groups of two to three 5th grade students, whereas in most other cases, even people meeting for the purpose of briefing or presenting the data, work mostly individually. This point is significant for schools that wish to adopt citizen science, adding a beneficial

social layer to all its advantages as an educational tool. Regarding the pro-environmental behavior aspects, according to a number of studies (Chawla 1999; Chawla and Cushing 2007; Cushing and Washburn 2014; Zhang et al. 2014) we may assume that the meaningful environmental experiences that 5th grade students have experienced will increase the possibility that they will act in the future as adults for the benefit of their environment.

## CONCLUSIONS

The 5th grade students of Alona School, who collected partial information to help preserve the Lesser Kestrel, contributed greatly to our understanding of the future of the Lesser Kestrel in the area. This data should raise a red flag amongst decision makers in nature conservation organizations in Israel, if they wish to continue seeing falcons in the Alona area. The students' answers contributed to an additional important aspect, showing how it is possible for citizen science to be integrated into formal education in elementary schools. According to their opinions, it was clear that it would be beneficial to conduct the surveys in small groups, contributing to social aspects of learning. Furthermore, the use of advanced technology would heighten the motivation enhancing the learning process, as did with these 5th graders, expanding their knowledge of the Lesser Kestrel. It is also recommended that teachers who combine teaching with citizen science spend more time conducting the survey, in which case the data received may be more complete.

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