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Mobile Apps for Recording Climate Change: A Case Study of Mobile Learning through Citizen Science in Four Urban Secondary Schools in India

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Abstract: *The Government of India has launched several ambitious initiatives to revolutionize the way India embraces technology in every sphere of its operations. In education in particular, e-learning as a tool is still not very widespread and there are presently few e-tools available to promote environmental education in schools. Mobile Apps for Climate Change, launched in 2014, was designed to help meet this need through developing and utilizing three mobile apps (iButterflies, iTrees, iNaturewatch Birds) to assist through citizen science documenting urban biodiversity. In an effort to introduce the apps and develop awareness of urban biodiversity, the apps were launched through a special challenge to students in classes from 6 to 8 in four metropolitan areas: Mumbai, New Delhi, Kolkatta and Hyderabad. Altogether 1599 students and 48 teachers from 32 schools from the four cities took up the Urban iNaturewatch Challenge beginning in January 2015 and concluding in April 2015. During this span, students collected 2227 records on 47 species of trees, 48 species of birds, and 50 species of butterflies. For correlation, tree phenology and flight periods of butterflies and birds were compared with temperatures at each location. In addition to encouraging scientific analysis, the iNaturewatch Mobile apps also were analyzed for pedagogical principles as place-based data collection tools, often considered to be most common type of app in science education. They are also classified as technology-based scaffolding and include conceptual scaffolds with visual and audio representations. This paper reports on issues related to usage of the iNaturewatch Mobile apps for climate change studies, engaging students outdoors for environmental studies, and the potential of students as citizen scientists in urban settings.*

1. Introduction

India today is enthusiastically embracing ICT. In order to transform the public services through the use of information technology, the Government of India has launched the Digital India programme with the vision to transform India into a digitally empowered society and

knowledge economy (Digital India Website)[2]. The progress of any nation depends on the system of education adopted by it to groom the next generation. With the proliferation of mobile technologies in all walks of life, there is a need for India to remodel and upgrade the current education delivery system. Several initiatives have been taken by the Government of India to promote e-learning. One of the most prominent among them is the "National Program on Technology Enhanced Learning (NPTEL)" by the Ministry of Human Resources Development. The mission of NPTEL is to enhance the quality of engineering education in India by providing free online courseware. NPTEL's mission is coincident with the introduction of m-learning (the use of mobile devices to deliver education anytime anywhere) into India's education sector, especially in the field of adult learning in rural areas. Mobile devices can be especially helpful in the quick conceptualisation of smart education systems. This is especially important in India, which has the second largest mobile phone user subscription base in the world, with over 900 million mobile phone users (Raman, 2015)[6]. However, as observed in Saudi Arabia by (Alrasheedi *et al*, 2015) [1], in India too, infusion of mobile technology into education, especially environmental education, is inhibited as most educational institutions have a 'no mobile' policy in place.

This paper discusses a pilot project, Mobile Apps for Climate Change, which introduced m-education in participating Indian schools. The aim of the project was to develop three Android mobile apps as Eguides for 50 commonly found indicator species of birds, butterflies & trees. The project also included a student citizen science programme in urban schools to collect data on the impact of climate change on urban biodiversity using mobile apps. Three mobile apps were developed to facilitate the project: iButterflies, iTrees, iNaturewatch Birds, collectively known as iNaturewatch Mobile Apps. These apps were used to collect data on urban biodiversity in four metropolitan areas: Mumbai, New Delhi, Kolkatta and Hyderabad. This was the first time in Indian schools where students used their mobile phones to complete a school project. As defined by Shih & Mills (2007) [8] and Traxler (2008)[10], iNaturewatch mobile apps fits the definition of m-Learning, which means anytime, anywhere learning capacity using multiple media functions like pictures, videos, text, and voice within the learner's comfort of space and time, spontaneity, interactivity, informality, and ownership of learning. This paper also discusses the pedagogical principles used in implementation of the project.

2. Project Issues: The *Mobile Apps for Climate Change* project addressed two main issues:

2.1 Cities are often very rich in biodiversity as they are located in very rich and fertile areas. As natural geographic areas, they typically have very high diversity of plants and animals. However, cities as human made environments need to learn how to co-exist with that biodiversity. With rich biodiversity, cities have enormous potential to mitigate climate change (Elmqvist, 2015)[3]. When this is considered in light of estimates that by 2050 the global urban population will double to 6.3 billion, population growth will affect urban ecosystems adversely, if not managed (CBD, 2012)[7].

In order to conserve urban biodiversity, documentation is important and currently is not done systematically. Post Conference of Parties (COP) 10, the Ministry of Environment of Forests and Climate Change (MoEFCC) of India initiated the People's Biodiversity Register (PBR) to address this deficit, however the work is progressing at a snail's pace. Therefore, involving common citizens in monitoring of flora and fauna will be helpful to bridge this gap and generate data that provides insights about climate change through observations of seasonal behavioral changes in urban biodiversity. Because birds, butterflies and trees are indicators of a

healthy urban environment, they were chosen as the research subjects for the project. Additionally, most of the necessary descriptive knowledge is readily available in field guides or scientific institutions but few e-learning tools are freely available. Having mobile apps to help in ready identification of common species of urban biodiversity was a first step in addressing this issue. However, like any citizen science project, the accuracy of the data collected needed to be validated. For the *Urban iNaturewatch Challenge,* team members served to evaluate the data and redundancies and obvious inaccuracies were removed. The use of these mobile apps in documenting urban biodiversity led to formulating four research questions that are presented with responses in the discussion section at the end of this paper.

2.2 It is claimed that many children are suffering from nature deficiency syndrome and that while children are increasingly comfortable with their gadgets indoors, they tend to avoid being outdoors (Louv, 2015)[4]. The authors sought to find ways of engaging children in a meaningful way to use the very same gadget to take them outdoors thereby reversing the process. Additionally, environmental studies have tended not to interest students in India because it is not a graded subject area. Students tend to spend their time on graded subjects and ignore ungraded subjects. Another drawback is that the curriculum is largely based on environmental problems rather than depicting positive aesthetic and ecological values of biodiversity. In this context, use of technology such as mobile apps could provide a novel and effective way of engaging students. In addition to learning to identify species, the students could be given more responsible tasks collecting data that could reflect on the impact of climate change on their immediate environment. While recognizing that the project served to motivate and engage middle level students in getting outdoors to collect species data and to increase environmental awareness rather than to serve as a scientifically valid database, the project team hope that the apps may ultimately be employed in collecting and posting scientifically valid data. In this case, the student citizen science programme wherein students used iNaturewatch mobile apps to record their findings and feed to the master database on the project website became an interesting yet challenging school project.

3. Methods

3.1 Content for apps & website: The mobile apps were inspired by the Audubon eguides and their framework was similar to these apps. The species selection was done on the basis of the most common species found in any urban area. A total of 50 species of birds, trees and butterflies were selected for inclusion in the apps with 447 photographs for species description. The pictures included male/female birds and butterflies, early stages of butterflies, and tree leaves, flowers, fruits, and barks. Birdcalls also were included the bird app.

As the project included a citizen science component wherein the users could report their sightings, a project website was developed for collecting and presenting the data. As the mobile apps were offline the data entry section was incorporated into the website. The website included guidelines of the study along with datasheets that could be downloaded if a school decided to use datasheets rather than the mobile phone. The online datasheet had preloaded information about the individual species.

3.2 Development of mobile apps and website: The authors engaged a digital advertising company, LycodonFx Pvt. Ltd. for development of the mobile apps and website. A dedicated

developer could take responsibility for maintaining the mobile apps and website beyond the project period. Ladybird Environmental Consulting (LEC) provided the designs and the apps were branded as iNaturewatch based on an LEC citizen science initiative. A iNaturewatch logo was designed and the website domain (www.inaturewatch.org) was created. The apps were individually named as iTrees, iButterflies, iNaturewatch Birds (see **Figure 1** for snapshots).

Figure 1. Snapshots of Mobile Apps

In addition to the mobile apps and website, an instructional video on usage of the apps and data entry on the website was developed to instruct teachers and students in how to use them. The video is available on Youtube (https://www.youtube.com/watch?v=6u5xbtBfgZE). A tutorial section was also embedded in the app along with the video link **(**see **Figure 2)**

Figure 2: Tutorial

3.3 Identifying schools for the citizen science programme: The team collaborated with environmental NGOs who had existing school programmes. In Mumbai, Greenline of Donbosco Development Society was chosen as they already had 50 city schools enrolled in their programme. For other cities, WWF-India was selected as they run nature clubs among schools across the country

One of the challenges faced by the project partners was school's policy of not allowing students to use mobiles in schools and many schools declined to participate for this reason. The approach was therefore changed for such schools. Instead of students, the teachers were asked to use their own mobiles for the project work. The team also provided individual tablets to each partner so that their staff could demonstrate the mobile apps for schools or use it while conducting sessions for students in the field.

4. Results

4.1 Publishing and Launching of Mobile Apps: The mobile apps and website were published on 12 December 2014 and were available for free download on Google Play Store. The launch events were planned throughout December 2014 at respective locations. During the project, downloads of each app ranged between 1000-5000 with ratings between 4.3- 4.6 out of 5. The project apps were downloaded from 11 countries around the world indicating that their usefulness was not confined to the project.

4.2 Urban iNaturewatch Challenge: To encourage student participation in the citizen science initiative, the Urban iNaturewatch Challenge was introduced during the launch. Due to the introduction of a competitive element that might encourage inflated reporting, the challenge meant that the emphasis of this initial project was less on reliable documentation and more on generating enthusiasm for and awareness of urban biodiversity. However, the project team anticipate the apps may be employed in other more scientifically verifiable activities. Under this challenge the highest number of sightings recorded by a particular school would "win" the competition. Participating schools agreed to consider the challenge as a student project ensuring that participating students received marks for carrying out the project. Classes 6-8 were selected and divided so that Class 6 studied trees, Class 7 Butterflies, and Class 8 birds. Each class had a group of 25-30 students. For school communication a circular and registration form was developed for all schools. A poster was developed and circulated among the schools and social media to promote the Urban iNaturewatch Challenge, Altogether 1599 students and 48 teachers from 32 schools from four cities had taken up the Urban iNaturewatch Challenge(see **Table 1).**

Table 1. Total Participating Schools and Students

City	No. of Schools	No. of Students
Mumbai	9	192
Hyderabad	7	603
New Delhi	6	96
Kolkatta	10	708
Total	**32**	**1599**

The project partners conducted orientation sessions for the teachers and students to understand the registration process. Both the project video and a slide-based presentation were provided. The orientation included briefing project participants on Climate Change, biodiversity, project objectives, the role of student scientists, and methods for collecting and filling the biodiversity datasheet. Additional outdoor visits also were conducted to provide experience using the apps and observation methods in the field.

4.3 Data Collection by Student Citizen Scientists: Data collection began in January 2015 and concluded in April 2015. The data was collected through eco clubs and nature walks organized by participating teachers. Students also collected data from nearby parks and gardens. Some students collected the data daily others reported sightings once per week. Students often found it easier to identify trees as compared to birds and butterflies. Many schools also lacked a proper green cover and thus had to choose a nearby park to complete the project. Some students also collected data from around their houses. The teachers also had to supervise the days when the students were allowed to bring their mobile phones for using the apps so that the device was not misused. Some schools identified one leader in each group who was given permission to bring their mobile phone on identified days. Some schools also allowed students to upload their data so the teachers did not have to take further time out from their normal duties.

Owing to the competitive spirit of the challenge the authors anticipated duplicate/incorrect entries. Thus, multiple entries from one user for a set of species on same date from same school and inaccurate data pertaining to a species from a particular city were removed. Due to the short duration of the project, valid scientific screening of data could not be completed. Project leaders plan to add this element in future project iterations.

(i) Species Diversity: Students recorded 47 species of trees, 48 species of birds and 50 species of butterflies from all four metros. Hyderabad recorded highest numbers of species, 41,45,41 respectively, followed by New Delhi (36, 29,15), Kolkatta (21, 30, 24) and Mumbai (34, 9,10). The diversity was primarily related to the participants' efforts in uploading the data and secondarily to the cities' urban biodiversity (see **Figure. 3**).

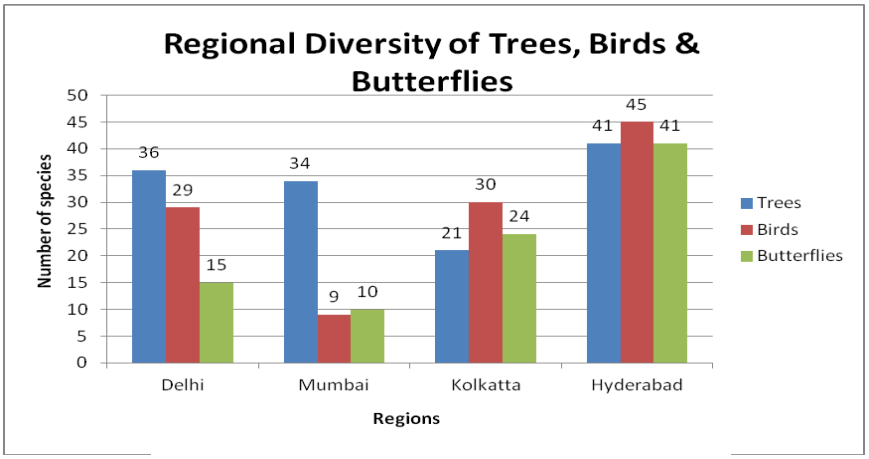

Figure 3. Diversity by Region

(ii) Tree Phenology: Students collected information on tree phenology including leaf fall, new leaves, flowering, fruiting and seed dispersal, important parameters to check for climate change impact on trees (Stirnemann *et al*, 2010)[9]. Any change in weather also affects tree phenology, thus helping identify climate change impact. Among the weather parameters, temperature was the most important parameter as it triggers natural cycles within trees. As seen in **Figure 4**, Hyderabad showed the highest records of leaf fall (n=61) at temperature 34^{o} C, while highest flowering and fruiting (n= 147, n= 107) at lowest temperature of 34^{o} C. Highest new leaves records (n=81) were observed for Mumbai at temperature of 36^{o} C..

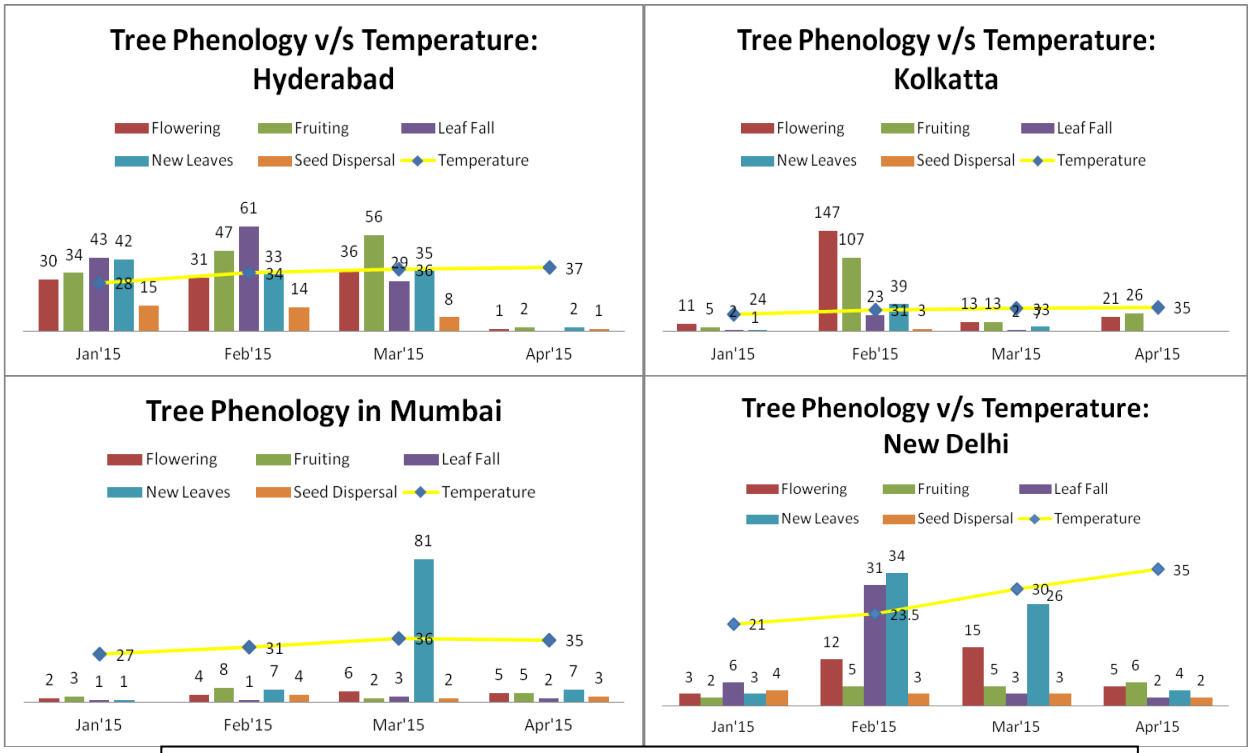

Figure 4. Correlation of Tree Phenology and Temperature.

(iii) Flight Period of Butterflies & Birds

Flight periods in butterflies and birds are affected by change in temperatures (Polgar *et al*, 2013)[5], (Wormworth & Mallon, 2006)[11]. Similar to the tree phenology data, the students collected data on flight period of butterflies and birds **(Figure 5)** and the highest butterfly and bird sightings were recorded in Kolkatta (n=234, n= 367) in February 2015 at temperature of 31^{o} C, followed by Hyderabad (n=81, n= 231) at slightly higher temperature of 34^{o} C. As discussed, results like these are primarily due to the efforts made by the students rather than an indication of higher diversity in a particular city.

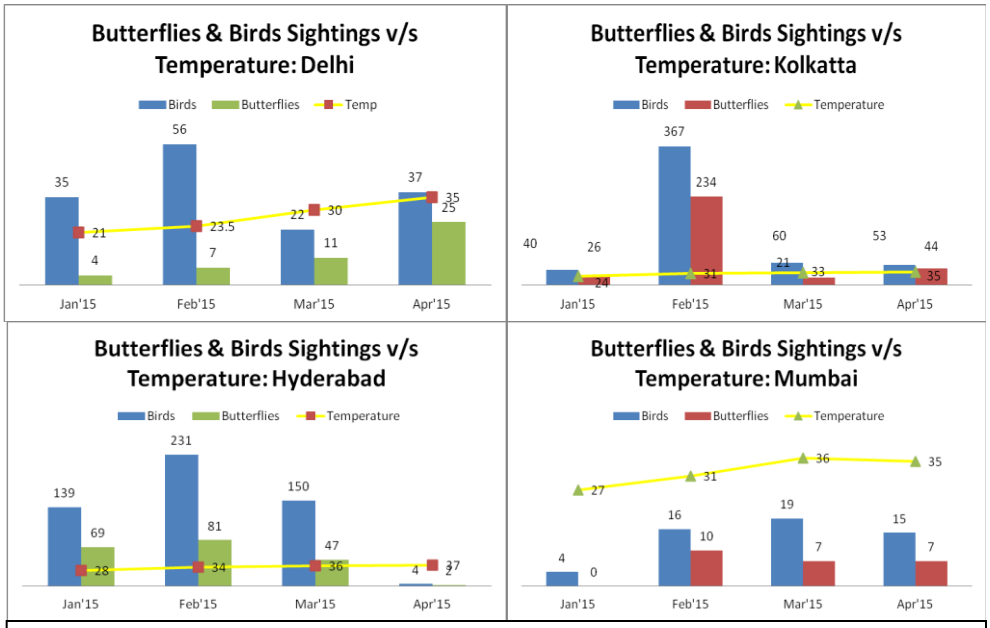

Figure 5. Correlation of Flight Period of Butterflies & Birds with Temperature

5. **Project Conclusion**: The Urban iNaturewatch Challenge concluded in April 2015 with a total 2227 records uploaded to the project website. To conclude the challenge a valedictory function was organized for all participating schools. The student teams were asked to make presentations of their data and winners were declared and celebrated in each project site. The project generated excellent media support due to its innovation in combining environment and education through technology and successfully attracted media coverage in most of the cities national and regional newspapers as well as TV channels. Numerous press reports released the following day certainly helped in creating much needed public attention. These press releases also acted as an incentive for the schools that participated in this initiative and in getting more schools to take an interest in it.

6. **Student and teacher feedback on the project:** A summary of feedback from project participants is provided below.

A majority of the teachers found the apps useful referring to them as the best way they had experienced in applying modern technology to a good use. The teachers reported that these apps enhanced student observation and listening skills and developed the attitude of appreciation. Teachers also stated that because of the apps students were now observing more things around them in detail. The teachers reported finding the apps to be very student friendly and enhanced their knowledge of birds and nature. The overall rating given by majority of the teachers was 8 out of 10.

The students found the project very useful as it imparted information on birds, trees and butterflies little known to them earlier. The students liked the fun section included in the app that allowed the users to test his/her knowledge on trees, birds and butterflies. Overall, students reported that it had been a fun and exciting experience and helped them learn many new things.

Students claimed that learning about trees; birds and butterflies through this app increased their interest in the conservation of wild life. Students rated the app 9/10 and were very keen to participate in similar programmes for nature conservation and environmental education. Students reported that the best part of the App was that one could browse the trees with the help of bark pattern and leaf shape.

7. Pedagogical analysis of iNaturewatch mobile apps and citizen science programme

Based on the theoretical framework for higher secondary education by Alrasheedi *et al*, (2015)[1], the project work fulfilled five characteristics of innovation: Complexity, Trialability, Observability, Compatibility, and Relative advantage (see **Table 2**).

Table 2. Analysis of theoretical framework

Complexity	Having multiple photographs of a single species such as bark, leaf, fruit, flowers for trees, male and female adults along with calls for birds, and male and female butterflies along with caterpillars and egg pictures
	Creating simple identification filters for ease of identification such as leaf shape, bark texture in case of trees, colours in case of birds and butterflies
	Providing tutorial and instructional video on how to use the app
	Providing a link to "record the sighting" for every species
	Datasheet with objective type and preloaded information about the species requiring minimal effort from the students
	Offline mobile app removes the internet barrier and cost
Trialability	The project adapted to existing student project works, thus not adding to the burden of students and teachers
	The project NGO partners were already working with the students, therefore facilitating the integration of the project activity with other ongoing activities
Observability	The mobile apps were specially designed for urban schools therefore a citizen science component was added to demonstrate the results of using the app
	The Urban iNaturewatch Challenge served to help students believe that they could participate in and contribute to scientific research.
Compatibility	The mobile app was an innovation as it proved to be first app that helped students with their environmental projects.
	Teachers found the app helpful in providing finger tip ready reference
Relative advantage	The mobile app replaced the usual way of field data collection by providing easier species identification and ready data entry if Internet was available

The iNaturewatch Mobile Apps fulfilled five of the six General Characteristics of Mobile Apps cited by Zydney & Warner (2015)[12]. Due to space limitations two characteristics, the technology-based scaffolding characteristics and the student outcome measures are reported here. The mobile apps comprise **technology-based scaffolding** as the information is provided in tiers to avoid overwhelming students. For example, if a student wants to know if the tree he/she

sighted is present in the mobile app, he/she will first open the 'Explore Trees' section with further tiers of identification filters for Bark and Leaf type. When they selected one category such as Leaf type, different types of leaves were listed. If they press the correct option based on the shape, it will open further into a collection of trees having similar leaves. Here if the tree in question is present in the app, it will show up in the list and pressing the right option will then open a page that has detailed information about the tree. The mobile apps are further classified into **Conceptual Scaffolds** as all relevant support information is provided within the app. If the student does not find the tree in question in the app, they could send pictures to an expert to seek guidance on identification. They could also send queries to participating experts online/offline.

The apps also fall under **Procedural scaffolds** as an instructional video was provided on how to collect and feed the data into the preloaded datasheets on the website. The website also included a list of instructions for schools to follow such as how frequently data need to be collected, why it is important to record repeat sighting, and why maintaining a standard time gap between two sightings was important for monitoring biodiversity.

Student outcomes measures demonstrated that the iNaturewatch Mobile apps provided cognitive outcomes in all three areas of lower-level (knowledge and comprehension); higher-level (analysis, synthesis, and evaluation); and cognitive load (factors that affect cognition).

i. Low levels of cognitive outcomes were measured by the understanding about the urban birds, trees and butterflies among the students.
ii. High level of cognitive outcomes were measured by the presentations done by the students on their project work wherein they analyzed the data collected by their teams and presented it the audience
iii. Cognitive load was measured in reports that the students became capable of remembering species names and were comfortable in speaking about their observations related to particular species.

Skill-based outcomes were also observed as the participating students became citizen scientists and learned methods of data collection in the field.

8. Discussion

This section provides discussion of research questions generated by the project.

(i) Can mobile apps be used for documenting climate change impact on urban biodiversity?

As demonstrated in Figures 5 and 6, the students were successful in collecting urban biodiversity data which could be correlated with weather parameters such as temperature, humidity and precipitation to ascertain tree phenology and flight periods of birds and butterflies at a given location. Owing to the short duration of the Urban Citizen Science Challenge, the data may not corroborate to indicate climate change impact. However, the data suggests that if data collection is planned in a systematic manner, the iNaturewatch mobile apps could be used for climate change studies. In that case, experts would need to validate the data before it is published.

Project experience suggests the following changes might make such studies more user-friendly:

- Converting the apps to Internet based operation so that the data entry could be directly made from the app rather than first on the app and then onto the website.
- Weather data could be directly gathered by the app rather than fed manually by the users.
- Providing offline storing of the records within the app and then synchronizing when Internet service is available.

(ii) Can environment as a subject be taught among secondary schools using iNaturewatch Mobile Apps?

The results strongly suggest that the iNaturewatch Mobile Apps have been successful in helping the students to complete their science projects. As the iNaturewatch Mobile Apps provided ready reference for urban biodiversity, teachers became more confident in dealing with the subject. Additionally, evaluation of the project results suggests the following changes might make the apps more effective:

- Increasing the species count from 50 to 100 to include more species across the country;
- Developing the apps for iOS and Windows platforms;
- As described by Zydney & Warner (2015)[12], adding a digital sharing feature allowing users to share their data on social media or among their teams
- Developing apps for other life forms such as amphibians, reptiles, mammals, wildflowers and Fungi could be additional indicator species helpful in mapping climate change impact.

(iii) Could mobile apps make outdoor learning more engaging for school students?

The iNaturewatch mobile apps were most useful when the users were outdoors. This was reported to be the first time that the Indian students found a mobile app for school project work. Collecting data was real and not a copy-paste job, often the case in school projects. For their periodic data collection sessions, the students ventured out in groups in and around their schools and homes to collect data. Several candidly confessed that whenever their parents scolded them for spending time on the mobile phones during the project they had a valid answer in saying that they were studying and not idling their time - even though it may have been a cover up at times.

(iv) Is it possible to develop student citizen scientists for environmental studies?

That the data results presented in the results section are solely the efforts of 1599 students and their teachers demonstrates that if the right resources are provided and properly guided, students have enormous potential to contribute environmental data and education as citizen scientists. Having an incentive such as competition and extra marks for project work also was observed to motivate students. This was first time that Indian students were involved in a biodiversity study through citizen science approach. As mentioned earlier, like any citizen science project, the data collected by citizen scientists needs validation from experts.

10. Conclusion

The Mobile Apps for Climate Change project was the first of its kind in using mobile technology for environmental studies in secondary schools in India. Data from the initial implementation demonstrated that the project created a pioneering opportunity for teachers to develop student projects with the iNaturewatch Mobile Apps while reducing the teacher's burden and developing scientific acumen among the students. Like any citizens science projects, the collected data needs to be authenticated by experts before it is used for scientific analysis. Long-term studies of this nature may result in documenting climate change impacts within cities and fostering the use of mobile apps as tools for urban citizen scientists.

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12. References

[1] Alrasheedi, Muasaad, Luiz Fernando Capretz, Arif Raza (2015). A systematic Review of the Critical Factors for Success of Mobile Learning in Higher Education (University Students' Perspective). Journal of Educational Computing Research 2015, Vo. 52(2), 257-276.

[2] Digital India Website: http://www.digitalindia.gov.in/content/about-programme (28.02.2016)

[3] Elmqvist, Thomas (Jan 2015). Cities and Biodiversity Stockholm Resilience Centre Retrieved www.stockholmresilience.org/21/research/research-news/6-8-2012-the-biodiverse-city.html (29.02.2016).

[4] Louv, Richard. (2005) *Last child in the woods: saving our children from nature-deficit disorder* Chapel Hill, NC : Algonquin Books of Chapel Hill.

[5] Polgar ,Caroline. A., Richard B. Primack, Ernest H. Williams, Sharon Stichter, Colleen Hitchcock (2013). Climate effects on the flight period of Lycaenid butterflies in Massachusetts**.** *Biological Conservation*, 2013; 160: 25

[6] Raman, Anupama (May, 2015). *Mobile learning: Smart education system for India*. http://forbesindia.com/blog/business-strategy/mobile-learning-smart-education-system-for-india/#ixzz41TpctgVM (28.02.2016).

[7] Secretariat of the Convention on Biological Diversity (2012) Cities and Biodiversity Outlook. Montreal. 64 pages

[8] Shih, Y. E., & Mills, D. (2007). Setting the new standard with mobile computing in online learning. The International Review of Research in Open and Distance Learning, 8(2):1–16.

[9] Stirnemann, R. , Pletsers, A. , Proctor, H. , Cooney, T., Caffarra, A. , O'Halloran, J. , Jones, M. and Donnelly, A.(2010). Climate change impacts on phenology: implications for terrestrial ecosystems. Phenology 2010 Conference, Trinity College, Ireland. https://www.tcd.ie/Botany/phenology/assets/docs/climatechangeposter.pdf (05.03.2016)

[10]Traxler, J. (2008). Podcasting in context. In G. Salmon & P. Edirisingha (Eds.), Podcasting for learning in universities (pp. 12–19). New York, NY: McGraw-Hill International.

[11] Wormworth, Jannice, Karl Mallon (2006). *Bird Species and Climate Change.* pp *75.* *www.climate.org/topics/climate-change/migratory-birds-climate-change.html* (05/03/2016)

[12] Zydney, Janet Mannheimer, Zachary Warner (2015). Mobile apps for science learning: Review of research. Computers & Education 94 (2016), 1-17.