Resources **2014**, *3*, 599-613; doi:10.3390/resources3040599

OPEN ACCESS

resources

ISSN 2079-9276

www.mdpi.com/journal/resources

Article

Subject Knowledge and Perceptions of Bioenergy among School Teachers in India: Results from a Survey

Pradipta Halder [1,*], Sari Havu-Nuutinen [2,†], Janne Pietarinen [2,†] Anas Zyadin [1,†] and Paavo Pelkonen [1,†]

[1] School of Forest Sciences, University of Eastern Finland, Joensuu 80101, Finland; E-Mails: anas.zyadin@uef.fi (A.Z.); paavo.pelkonen@uef.fi (P.P.)

[2] School of Applied Educational Science and Teacher Education, University of Eastern Finland, Joensuu 80101, Finland; E-Mails: sari.havu-nuutinen@uef.fi (S.H.-N.); janne.pietarinen@uef.fi (J.P.)

† These authors contributed equally to this work.

* Author to whom correspondence should be addressed; E-Mail: pradipta.halder@uef.fi; Tel.: +358-40-74-70711.

External Editor: Witold-Roger Poganietz

Received: 24 June 2014; in revised form: 15 September 2014 / Accepted: 9 October 2014 / Published: 15 October 2014

Abstract: Teachers' knowledge and perceptions of bioenergy, and their motivation to teach such a topic, can largely determine the success of implementing bioenergy related education in schools. The study aimed to explore science teachers' knowledge and perceptions of bioenergy in India. A questionnaire-based survey was conducted among 28 science teachers from four urban schools in India. Results indicated that the science teachers were fairly knowledgeable regarding bioenergy and they also demonstrated positive perceptions of bioenergy. In addition, they were positive towards the prospect of receiving more information to increase their own knowledge of bioenergy. However, the science teachers appeared to have some misconceptions regarding the issue of CO_2 emission from using bioenergy. It also emerged that although the existing Science syllabus for Grade X in Indian schools includes a topic on bioenergy, the majority of the science teachers were not aware of it. Policy makers and educators are recommended to provide science teachers more support to improve their capacity for teaching energy and environmental topics in schools in India. In addition, an improvement of the current learning and teaching environment in Indian schools could help teachers to deliver energy and environmental education more effectively to their students.

Keywords: bioenergy; teachers; knowledge; perceptions; India

1. Introduction

There is a growing consensus among educators and environmental professionals that a solution to the present day environmental crisis will require an enhanced environmental awareness, which should be deeply rooted in the education system at all levels [1]. In 2002, the United Nations declared the time period 2005–2014 as the United Nations Decade of Education for Sustainable Development (DESD), and since then, ESD has received an increased political consensus for its integration at all educational levels [2]. It is widely agreed that the energy is the prime mover of our civilization and that energy issues can influence all three pillars of sustainability (*i.e.*, ecological, economic, and social) in both positive and negative ways. School students are the future citizens of a country, and unless they are aware of the pressing environmental and energy related challenges and their relationship with sustainable development, such problems cannot be solved effectively. In this context, the role of school teachers becomes highly significant, as they can play a key role in advancing environmental education (EE) efforts and in increasing environmental literacy of the future generations [3]. In a broader sense, teachers can also play a key role to promote ESD in schools, as schools are the first level of formal education in our modern society. Chedid [4] also suggested that "teachers are the primary link for preparing students for the future energy related jobs" and Seraphin *et al.* [5] emphasized that "teachers should have high levels of proficiency and confidence in their ability to teach energy science in schools". However, it has been found that insufficient teacher knowledge related to energy and environmental subjects is a limiting factor for the promotion of EE in schools [6]. In many cases, a loophole appears to lie in the absence of environmental interests and in teachers' negative attitudes towards this subject [7]. In addition, Sonowal [8] has reported that "teachers are not motivated to go beyond regular class schedules due to some constraints and even (then,) it becomes difficult for them to adjust the specific environmental activities in the regular course schedule". Therefore, it could be challenging for teachers to teach renewable energy related topics to their students, as such topics are often decontextualized, although they could be relevant for young students to obtain a basic awareness at an early stage.

Bioenergy is currently the most widely used renewable source of energy in the world, and the expansion of modern bioenergy technologies is gaining momentum in a large number of countries. However, a major challenge for bioenergy related education in schools is the fast developing and greatly diversified bioenergy industry, as biomass resources and their conversion technologies for energy production are highly heterogeneous. It requires school curricula to be updated frequently, while teachers should bring new information on bioenergy for their students almost every day. Different schooling systems and school environments also pose a challenge for policy makers to introduce a common set of curricula that can include all the important aspects of scientific developments in our society, such as the development of modern renewable energy technologies. Liarakou et al. [9] suggested that "when teachers are knowledgeable and well disposed towards renewable energies, they will be capable [of integrating] relevant knowledge and values into the curriculum or in extracurricular environmental education programs". It can be expected that when teachers value the introduction of a sustainable energy

module into school curriculum, such a module could influence students' knowledge and attitudes related to the pressing energy issues of our society. Therefore, teachers' motivations to teach bioenergy as a topic in the science curriculum in schools could raise students' awareness of bioenergy at an early stage of their development. However, it is not only bioenergy education that is challenging to implement in schools; Seraphin *et al.* [5] have reported that "there is relatively little implementation in the classroom of energy science curriculum that deals with energy generation or energy consumption despite teachers' high levels of interest in the subject".

1.1. Energy Education in Indian Schools

India is an emerging economy and the recent economic development has increased the country's energy consumption enormously, which is expected to continue well into the future to maintain the economic growth. At present, around 95% of India's commercial energy demand is met by fossil fuels, mainly from coal, natural gas and imported oil. However, about 70% of Indians depend on traditional biomass for cooking and heating, and such dependency is almost 90% in rural areas of the country [10]. In recent years, the Government of India (GoI) has adopted several policy measurers to increase energy production from biomass to reduce the country's dependency on fossil fuels and tackle climate change. Although several universities and research institutions in the country are engaged in providing bioenergy related education and training for engineers, bio-technologists and technicians, it is not clear how modern renewable energy related topics are addressed in Indian schools. There is almost no information available on Indian teachers' subject knowledge and perceptions of different renewable energy technologies, including bioenergy, and without knowing these facts it is difficult to recognize the current state of the implementation of renewable energy education in Indian schools. The present study is significant from this perspective as it attempts to address this under-researched area in an Indian context. According to Shulman [11], teachers' subject knowledge can be of two types: *substantive knowledge* or *syntactic knowledge,* where the former refers to the knowledge of facts, concepts, and processes of the topics while the latter indicates the knowledge of the discipline. Although this categorization of subject knowledge was made concerning the topic of mathematics, the concept has also been applied to other scientific topics such as physics and engineering [12–14]. However, subject knowledge of bioenergy, in the context of the present study, is regarded as science teachers' conceptualization of bioenergy based on the scientific facts, *i.e.*, knowing the processes, applications, and outcomes or impacts, whereas their perceptions of bioenergy refer to their initial thoughts on bioenergy.

India is a highly diversified country when it comes to the school education systems of the 29 States and 7 Union Territories (UTs) that constitute the country. The Indian education system is the second largest in the world after China's [15]. The National Council of Educational Research and Training (NCERT) under the Department of Education is responsible for developing school curriculum, syllabus, and textbooks for schools based on the guidelines in the National Curricula Frameworks, the most recent of which came into being in 2005, whereas the previous one was prepared in 2000 [16]. Although recommended, it is not mandatory for the States and UTs to adopt the NCERT prescribed curricula and textbooks. Therefore, large variations exist in the school curricula, syllabus, and textbooks in the States and UTs that do not strictly follow the NCERT recommendations and have instead introduced their own set of school curricula and textbooks. India's comprehensive schooling system is based on three stages

that last for ten years. In most of the States and UTs, primary stage comprises Grades I to V; upper primary stage comprises Grades VI to VIII; and secondary stage consists of Grades IX to X. The higher secondary stage is part of the tertiary education system and comprises Grades XI and XII. Students usually complete their secondary stage of education at approximately 15 years of age.

Teaching Science and Environmental Studies in schools starts at the primary stage in almost all States and UTs [16], and EE is now a compulsory part of the syllabus in schools throughout the country [17]. The format for Science curricula has recently been revised by the NCERT in order to organize the scientific themes to be more cross-disciplinary in nature. At present, a common set of scientific themes is followed, starting from Grade VI to Grade X, and these are as follows: Food, Materials, The World of the Living, How Things Work, Moving Things, People and Ideas, Natural Phenomena, and Natural Resources. The revision of the Science syllabus has been performed in order to encourage students to ask key questions on various natural phenomena and thus stimulate their critical thinking skills. In particular, energy topics are now part of the syllabus for Grade X under the theme of Natural Resources; however, some basic topics related to fossil fuels are also included in the Science syllabus for Grade VIII (Table 1). Inclusion of energy related topics in the Science curricula in schools presumes and demands that the science teachers have sufficient subject knowledge of energy topics and be able to teach renewable energy related topics to their students according to the relevant scientific base. It is also expected that such teaching should not only confine to classrooms and the teachers should encourage their students to learn more about energy and environmental issues through extracurricular activities such as participating in school debates and scientific exhibitions.

Table 1. Syllabus for Energy studies in Grade VIII and Grade X under the revised science curricula (Adapted from [16]).

Theme/*Sub-Theme*	**Questions**	**Concepts**	**Resources**	**Activities/Processes**
Grade VIII				
Natural Resources/*Man's Intervention in Phenomena of Nature*	What do we do with coal and petroleum? Can we create coal and petroleum artificially?	Formation of coal and petroleum in nature. (Fossil fuels?). Consequences of over extraction of coal and petroleum.	Background materials, charts *etc.*	Discussion
Grade X				
Natural Resources/*Energy*	What are the various sources of energy we use? Are any of these sources limited? Are there reasons to prefer some of them over others?	Different forms of energy, leading to different sources for human use: fossil fuels; solar energy; biogas; wind, water and tidal energy; nuclear energy. Renewable *versus* non-renewable sources.	Experience; print material on various sources of energy; materials to make a solar heater.	Discussion. Making models and charts in groups. Making a solar heater/cooker.

In India, the number of full-time teachers teaching at the secondary and higher secondary levels was about 1.05 million and 0.37 million respectively in 2002, and among this large number of teachers, about 83%–87% were trained [18]. In addition, there are also a large number of part-time teachers in Indian schools, predominantly at the primary and upper primary levels, who are teaching a variety of subjects

and who are often underqualified and untrained. The learning environment, especially in rural public schools in India, is severely affected by the absence of minimum basic facilities and most of them are often understaffed [15]. Moreover, teacher empowerment is a critical issue in India as the present initiatives in this direction are not effective to empower science teachers, resulting in a lack of motivation and confidence on behalf of the teachers [19]. In this situation, an effective delivery of science education in schools is a challenging task for the teachers. To improve the delivery of EE in schools, NCERT has developed some pre-service and in-service training materials for teachers [19]; nevertheless, the quality of most of the in-service training materials is questionable [17].

1.2. Literature Review

In recent years, a number of studies have analyzed both primary and secondary school teachers' (including trainee teachers) knowledge, perceptions, and attitudes related to different environmental issues. Such studies can be classified into two broad categories. The first category of studies has explored teachers' knowledge and perceptions of issues such as sustainability, global warming, biodiversity, nature, ozone depletion, and acid rain [20–22]. The second category of studies has focused on themes such as waste management, biotechnology, and energy concepts [23–25]. In general, it has been found from these studies that environmental awareness among teachers is generally fair, although their reasoning of the underlying causes of environmental problems appears to be poor [26]. Regarding energy conceptions among teachers, Trumper [27] indicated that elementary school teachers in Israel had several misconceptions of energy and that their conceptual clarity of energy did not follow the scientifically accepted concepts. Diakidoy and Iordanou [23] also found that the knowledge of energy as a scientific concept among teachers and pre-service teachers in Cyprus was not very satisfactory and that the teachers had difficulties in distinguishing between concepts such as "energy" and "force". Such difficulties among teachers in understanding energy concepts can be attributed to the fact that energy concepts are intrinsically complex and difficult to understand conceptually [28].

Although in recent years a growing number of studies have analyzed secondary school students' knowledge, perceptions and attitudes related to bioenergy [29–31], there are not many studies that have focused on analyzing teachers' knowledge and perceptions of different renewable energy technologies. To this direction, Liarakou *et al.* [9] conducted a study among secondary school teachers in Greece to analyze their knowledge and attitudes related to renewable energy sources. Their study found that the teachers were knowledgeable about different renewable energy sources; however, the teachers did not express any clear position on several issues related to renewable energy and sustainability. Their study did not include bioenergy and it mainly focused on wind and solar energy technologies. In a recent study, Zyadin *et al.* [32] found that secondary school teachers in Jordan had very limited knowledge of renewable energy, though they showed positive attitudes towards such technologies. Their study included bioenergy and they found that the Jordanian teachers had some misconceptions regarding the renewability of bioenergy sources and the use of feedstock for biodiesel, and they appeared to be uncertain on the linkage between biofuels production and food crisis. In another study, Çelikler [33] explored Turkish trainee teachers' awareness of renewable energy. The study found that the pre-service science teachers in their third year of training were more aware of renewable energy compared to the

trainee teachers in first and second years, due to the reason that the third-year trainee teachers participated in some courses where they were taught about different renewable energy technologies.

1.3. Aims of the Study

The primary aim of this study was to investigate school teachers' subject knowledge and perceptions of bioenergy in an Indian context. The secondary aim was to explore their views about the possibilities of teaching bioenergy as a topic in schools. The study also intended to provide a few recommendations on improving science teachers' knowledge of bioenergy and their capacity to teach bioenergy in schools. Finally, this study also aimed to open up the possibilities for future studies with nationwide data from Indian schools to arrive at more precise empirical evidence on the topic.

2. Method and Data

The study employed a questionnaire-based survey among 28 full-time science teachers in four schools in New Delhi and Bengaluru in India. The questionnaire consisted of multi-item close-ended questions in four sections. The first section included questions related to the science teachers' socio-demographic profiles (e.g., age, gender, years of teaching experience, educational qualification, subject of specialization, and subject of teaching). The second section consisted of questions related to their subject knowledge of bioenergy and their sources of information on bioenergy. Their subject knowledge of bioenergy was analyzed on a four item 'True-False' scale. The third section used a six-item seven-point Likert scale that included items to analyze the science teachers' perceptions of bioenergy. The coding for the Likert scale was given as Strongly agree = 7, Agree = 6, Somewhat agree = 5, Neither agree nor disagree = 4, Somewhat disagree = 3, Disagree = 2, Strongly disagree = 1. The fourth section consisted of questions related to their views about the possibility of teaching bioenergy in their schools.

The selected four schools belonged to a network of schools that participated in different EE related projects of The Energy and Resources Institute (TERI, India). The schools were approached by a TERI researcher and permission to conduct the surveys was obtained from each school. The survey was confined only to the science teachers in those four schools, and all of them participated in the survey. Teachers from other disciplines such as arts, humanities, and commerce were not considered as a target group for the study. It was considered that it would be most relevant to include only the science teachers as they are responsible for teaching scientific topics in schools, and energy related topics fall under the science curriculum. The items of the survey instrument were developed through an extensive literature review and by consulting several energy education experts. Since all of the selected schools followed English as their medium of instruction, the questionnaire was prepared only in English. A researcher from TERI sent the questionnaires to the schools by post; after the survey was conducted, the schools returned the questionnaires to the TERI researcher. All of the science teachers participated in the survey voluntarily and there was no incentive for participation.

Among the 28 science teachers who participated in the survey, 80% were female and the mean age of the respondents was 35 years (SD = 7.75). The average teaching experience of the respondents was 8 years (SD = 5.81). The majority (ca. 61%) of the science teachers had a Master's degree while about one-third of them had a Bachelor's degree in one of the common science-related subjects (e.g., Physics,

Chemistry, Mathematics, and Biology). Both descriptive and non-parametric statistical tests were performed to analyze the data. The use of non-parametric tests was considered appropriate due to the small sample size in the study and that the data also appeared to be skewed towards the female respondents. Statistical analyses were performed by the SPSS 19 software package.

3. Results

3.1. Teachers' Subject Knowledge of Bioenergy

Teachers' subject knowledge of bioenergy was measured with the help of a four-item 'True-False' scale (Table 2). The four items measured the teachers' knowledge of facts, concepts, and processes related to bioenergy. Three of the four items (Items 1-3) were related to the most commonly accepted attributes of bioenergy. However, Item 4 was structured in a way that expected the teachers to have an advanced knowledge on the topic as it was linked to the carbon neutrality of bioenergy. Moreover, the phrasing of Item 4 was constructed differently, to check for the *acquiescence (yes set) response bias* among the respondents. The results showed that the majority of the science teachers knew that bioenergy was a renewable source of energy (Item 1), that it could be used in liquid form in motor vehicles (Item 2), and that it could also be used for electricity production (Item 3). Nevertheless, about 29% of the teachers did not appear to know that bioenergy could be used in a liquid form in motor vehicles. Regarding Item 4, only a minority of the teachers (ca. 23%) appeared to know that the use of bioenergy could release carbon dioxide (CO_2) into the atmosphere. Gender parity appeared between the teachers in terms of their knowledge of bioenergy. It showed that among the respondents who answered all of the questions correctly, the percentage of male and female respondents was quite similar. Almost all the science teachers affirmed that they were familiar with bioenergy and had come to know about bioenergy from newspapers, books, T.V., and the internet. All of them also stated that they would be interested to receive more information on bioenergy, and about 70% of them affirmed that the internet would be their preferred source for receiving information on bioenergy.

Table 2. Science teachers' responses to the "True-False" scale that measured their subject knowledge of bioenergy.

	Items	Teachers' Responses	
		True	False
1.	Bioenergy is a renewable source of energy (n = 27)	93%	7%
2.	Bioenergy can be used in liquid form in motor vehicles (n = 21)	71%	29%
3.	Bioenergy can be used for electricity production (n = 23)	100%	-
4.	Use of bioenergy does not release carbon dioxide (CO_2) into the atmosphere (n = 22)	77%	23%

3.2. Science Teachers' Perceptions of Bioenergy

A seven-point Likert scale consisting of six items was used to analyze the perceptions of bioenergy among the science teachers in this study (Table 3). It appeared that the majority of them (ca. 86%) perceived that the use of bioenergy could reduce the threat of global climate change (Item 1). The coefficient of variation (CV) was 21%, which denoted a low dispersion in the respondents' perceptions of this issue. A statistically significant difference with a medium effect size (denoted as r) appeared

between the male and female respondents in relation to their perceptions of this notion (U = 21, $Z = -2.38$, $p = 0.017$, $r = 0.45$). The female respondents appeared to be more positive (*Mean rank = 16.09*) in their perceptions than the male respondents (*Mean rank = 7.20*). Around 92% of the respondents agreed that domestically produced bioenergy in India could reduce the country's dependency on imported energy sources from other countries (Item 2). The female respondents appeared to be more positive (*Mean rank = 15.46*) in their perceptions of this notion than their male counterparts (*Mean rank = 10.10*). The CV was 19%, which indicated a low relative variability in the respondents' perceptions of this notion. Regarding the proposition that use of biofuels could reduce the use of gasoline and diesel in motor vehicles (Item 3), almost 90% of the respondents showed positive perceptions, and the CV was low. There was a statistically significant difference (U = 18, $Z = -2.58$, p = 0.010, r = 0.48) with a medium effect size between the male and female science teachers in their perceptions of this notion. Quite similar to the previous two items, the female respondents appeared to be more positive (*Mean rank = 16.22*) compared to the male respondents (*Mean rank = 6.60*).

About 84% of the respondents agreed that energy production from biological materials was necessary for the progress of the human society, while only 7% disagreed (Item 4), and the CV was low. The female respondents appeared to be slightly more supportive (*Mean rank = 14.43*) of this notion compared to the male respondents (*Mean rank = 12.10*). A little over half of the respondents agreed that the use of biological materials for energy production could reduce their availability for other uses, whereas about 28% of the respondents disagreed (Item 5). The relative variability appeared to be medium (CV = 41%). The female science teachers were also more in agreement (*Mean rank = 13.63*) with this notion compared to the male science teachers (*Mean rank = 10.50*). On the issue of whether bioenergy could destroy biological resources on the earth, the majority of the respondents disagreed with this proposition while about 27% agreed, and the CV was moderate.

3.3. Science Teachers' Views about Teaching Bioenergy in Schools

There were four questions related to the science teachers' views about teaching bioenergy in the schools. In the first question, the science teachers were asked whether they thought that their students should be aware of bioenergy, and the majority (ca. 86%) responded positively. The second question asked the science teachers to confirm whether bioenergy was included as a topic in their school curricula. About 66% and 27% of the respondents' answers were positive and negative respectively. To investigate further, the respondents who answered positively were asked to confirm the grade and subject where bioenergy was included as a part of teaching in their schools. A variety of information emerged from the respondents' answers to this question. In terms of subjects, the respondents stated subjects such as biology, environmental science, social science, geography, and environmental education. In terms of grades, the respondents confirmed a range of grades from II to XI. In another question, the science teachers were asked about the further possibility of teaching bioenergy in their schools. All of them responded positively. Finally, the science teachers were asked to name the best possible sources from which their students could learn about bioenergy. The most common source given was school teachers, followed by newspapers, science books, science magazines, internet, and T.V.

Table 3. Perceptions of bioenergy among science teachers in India.

Items	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree	Mann Whitney U-Test (*p* Values)
								Gender
1. Use of bioenergy can reduce the threat of global climate change (*n* = 28, S.E. = 0.24, CV = 21%)	43%	43%	0	7%	3%	4%	0	0.017 *
2. Domestically produced bioenergy in my country can reduce the dependency on importing energy from other countries (*n* = 28, S.E. = 0.22, CV = 19%)	32%	35%	25%	4%	0	4%	0	0.193
3. Use of bioenergy as a fuel in motor vehicles can reduce the use of petrol and diesel (*n* = 28, S.E. = 0.24, CV = 20%)	46%	39%	4%	4%	3%	4%	0	0.010 *
4. Energy production from biological materials is necessary for the progress of human society (*n* = 27, S.E. = 0.22, CV = 20%)	22%	44%	18%	7%	7%	0	0	0.564
5. Use of biological materials for energy production could reduce their availability for other uses (*n* = 25, S.E. = 0.38, CV = 41%)	16%	24%	16%	16%	4%	20%	4%	0.408
6. Use of biological materials for energy production could destroy biological resources on earth (*n* = 26, S.E. = 0.30, CV = 45%)	4%	4%	19%	11%	23%	35%	4%	0.973

Notes: S.E. = Std. Error of Mean; CV (coefficient of variation) has been calculated by dividing the standard deviation by the mean and multiplied by 100%. Standard deviation and mean for each item in the table have not been reported. * = statistically significant ($p < 0.05$).

4. Discussion

The study explored science teachers' subject knowledge and perceptions of bioenergy from four schools in India. The sample size of science teachers in the study was relatively smaller compared to some other studies, which analyzed teachers' knowledge, perceptions, and attitudes related to environmental and energy issues in India and elsewhere [7,23,34]. Therefore, the results from this study cannot claim to be representative of an Indian context. In addition, there could be a potential bias due to the selection process of the schools for this study. The schools which took part in the survey were approached through TERI, and all the schools had previously participated in different EE related projects conducted by TERI. This could have influenced the science teachers' knowledge and perceptions of bioenergy. Nevertheless, the study was among the first efforts that attempted to explore science teachers' knowledge and perceptions of bioenergy in an Indian context, which has remained under-researched in India to date.

In this study, the science teachers appeared to have a fair amount of subject knowledge of bioenergy, especially regarding its renewability, its possibility to be used in motor vehicles in liquid form, and its role in producing electricity. Therefore, these findings support the findings from a previous study, which found a high level of environmental knowledge among science teachers in India [34]. However, the majority of the science teachers in this study appeared to be ignorant of the fact that the use of bioenergy can release CO_2 into the atmosphere. Release of CO_2 can occur from biomass combustion in power plants as well as emission from biofuel-driven motor vehicles. In India, the traditional way of burning biomass for cooking is very common in rural areas and also among the urban poor. Such a practice releases CO_2 and other gases, and is a major cause of health problems among the poor due to indoor pollution. Therefore, this ignorance indicates a lack of *substantive knowledge* of bioenergy among the science teachers. It further indicates that it would be practical to improve science teachers' subject knowledge of bioenergy so that they can teach it with high confidence to their students. This is also relevant as Seraphin *et al.* [5] have suggested that when teachers have a strong scientific base in energy science, only then will they be able to identify and challenge students' misconceptions and help their learning process. The science teachers appeared to be positive towards receiving more information on bioenergy; therefore, it might be possible to encourage them to participate in content-based training courses where they become aware of bioenergy related topics, improve their subject knowledge, and enhance their capacity to teach such topics in schools. In addition, where possible, study tours could also be organized for science teachers, in modern bioenergy plants such as a biomass-based power station or an ethanol producing plant in a sugar mill, as such practical activities could improve the teachers' subject knowledge of bioenergy and remove some of the misconceptions that they may have about the subject.

Science teachers' perceptions of bioenergy showed that they were positive about the potential contribution of bioenergy towards mitigating global climate change and reducing dependency on fossil fuels. On one hand, they supported the current practice of energy production from biological materials for meeting societal needs and did not perceive that such a practice could destroy the biological resources on the earth. On the other hand, they were concerned that the use of biological materials for energy production could reduce their availability for other uses. There have been intense discussions going on between scientists, the public, and civil societies related to the potential negative impacts of increasing

bioenergy use on biodiversity, natural resources, and availability of biomass for other societal uses [35,36]. Therefore, the science teachers' perceptions of bioenergy in this study somehow reflected the ongoing debates on bioenergy in society, which have both positive and negative directions. Stern *et al.* [37] have claimed that the individual's environmental concern has three value dimensions: *social-altruistic* (*i.e.*, concern for the welfare of other human beings), *biospheric* (*i.e.*, concern for nonhuman species), and *egoistic* (*i.e.*, self-interest). The present study did not attempt to analyze teachers' perceptions of bioenergy by applying this tripartite value orientation model, yet the results indicate the existence of such value dimensions, particularly *social-altruistic* and *biospheric* among the science teachers, related to their perceptions of energy production from biological resources.

No significant gender difference appeared between the male and female teachers in their perceived concerns regarding energy production from biological materials; such similar results of gender neutrality in environmental concerns were also found in a study by Alibeli and White [38]. The result of the present study was, however, opposite to the findings by Ribeiro *et al.* [39], who found that in Portugal, female residents perceived bioenergy technology as more threatening to the environment than did males. Therefore, future studies could use the model developed by Stern *et al.* [37] to analyze teachers' concerns regarding bioenergy more profoundly. Significant gender differences appeared in this study between the science teachers, related to their perceptions of the usefulness of bioenergy for mitigating global climate change and reducing the use of fossil fuels, which showed that compared to the male science teachers, the female science teachers were more positive about bioenergy. In general, similar stronger environmental orientation and energy consciousness among women than men were found in a number of previous studies [32,40], and also in the case of bioenergy [41].

Almost all the science teachers in the study agreed that their students should be aware of bioenergy and that teaching such a subject in their schools should be possible. However, there were inconsistencies in the science teachers' responses concerning the grade and subject where bioenergy was included as a topic in their schools. They suggested a variety of grades and subjects related to bioenergy, and there was much discrepancy in the science teachers' views even within the same school. In fact, at present, only the revised Science syllabus of Class X, includes a bioenergy related topic, under the theme *Natural Resources* [16]. Only a minority of the science teachers recognized that bioenergy was included as a topic in Class X, which indicated that although bioenergy was part of the Science syllabus it was not optimally integrated into the subjects to be taught in schools. Notwithstanding this deficit in teaching of bioenergy in schools, the majority of the science teachers considered that their students should be able to learn about bioenergy from school teachers. This perhaps reflected a sense of responsibility among the respondents to teach new topics to their students and, at the same time, their recognition of bioenergy as a topic that their students should be aware of. On a positive note, it can be said that the science teachers' motivation to teach bioenergy in schools and their own interests in learning more about bioenergy could help the introduction and effective teaching of a decontextualized topic such as bioenergy in school curricula, which is otherwise a challenging topic to teach students at a school level.

5. Conclusions

The findings from this study indicate that the science teachers had a fair knowledge of bioenergy and they also showed positive perceptions of bioenergy. In addition, they appeared to be interested in

receiving more information on bioenergy to increase their knowledge of the subject. The study addressed the relatively under-researched topic of teachers' knowledge and perceptions of bioenergy in an Indian context; however, due to a small sample size, the policy relevance of the findings may appear to be limited. Nevertheless, the findings might serve as a pre-study and cognitive pre-test for the questionnaire, which surely deserves to be distributed to a much larger number of participants, coming from a more diverse range of schools. Results from such an approach could help policy makers and educators to formulate better energy education strategies in Indian schools, by providing teachers with more opportunities to implement such strategies. However, it appears that even though the existing NCERT syllabus includes topics on bioenergy, it is not addressed with significance by many of the teachers when they are teaching energy topics to their students. In this context, it is pertinent to find out the quality of teaching of energy topics in schools in India, as it is directly related to the students' learning of energy science in the context of EE and ESD. Therefore, inclusion of a bioenergy related topic in textbooks will not be overly helpful unless the teachers are motivated to teach such a topic with substance and employ extra-curricular methods to raise students' interests in those topics. As this study is limited to four schools in two large Indian cities, future studies need to recruit more schools from both urban and rural areas of India to obtain a broader picture of science teachers' knowledge and perceptions of bioenergy as well as the status of renewable energy education in schools. It will be of much relevance to explore the co-curricular and extra-curricular opportunities by which teachers can increase students' awareness of energy and environmental issues, particularly in rural schools, as most of the rural schools in India are severely affected by the absence of basic teaching facilities. It will also be beneficial to include teachers from other disciplines, as energy and environmental issues are cross-disciplinary in nature and, therefore, the teachers' awareness and perceptions of those issues will be relevant in developing the future EE and ESD curriculum for schools. Thus, empowering teachers is an absolute prerequisite in India in the context of implementing effective ESD curriculum for schools.

Acknowledgments

The authors are thankful to the anonymous reviewers for their suggestions, which helped to improve the manuscript. The authors are also thankful to the schools and teachers for their cooperation in the study. The authors would like to thank Ranjana Saikia and Taru Mehta from The Energy and Resources Institute, New Delhi, India for their assistance in conducting the surveys in the schools. The Postdoctoral research grant from the Kone Foundation (Helsinki, Finland) is greatly acknowledged for realizing this study. Finally, the Institute for Natural Resources, Environment and Society (LYY), based at the University of Eastern Finland, is also acknowledged for allocating a grant to the author that was paid to a professional for improving the language of the article.

Author Contributions

Pradipta Halder is the main author and was responsible for conceptualizing the study, designing the survey instrument, collecting and analyzing the data. Sari Havu-Nuutinen, Janne Pietarinen and Paavo Pelkonen were the scientific collaborators, who contributed in designing the survey instrument, guided the work, critically reviewed the manuscript and suggested adequate revisions. Anas Zyadin contributed in analyzing the data and providing critical feedback to the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. Khan, S.H. A study of attitude towards environmental awareness in relation to certain variables among senior secondary school students. *Glob. Res. Anal.* **2013**, *2*, 42–44.
2. Wals, A. *Shaping the Education of Tomorrow. 2012 Full-length Report on the UN Decade of Education for Sustainable Development*; The United Nations Educational, Scientific and Cultural Organization: Paris, France, 2012.
3. World Commission on Environment and Development (WCED). *Our Common Future*; Oxford University Press: Oxford, UK, 1987.
4. Chedid, L.G. Energy, society, and education, with emphasis on educational technology policy for K-12. *J. Sci. Educ. Technol.* **2005**, *14*, 75–85.
5. Seraphin, K.D.; Philippoff, J.; Parisky, A.; Degnan, K.; Warren, D.P. Teaching energy science as inquiry: Reflections on professional development as a tool to build inquiry teaching skills for middle and high school teachers. *J. Sci. Educ. Technol.* **2013**, *22*, 235–251.
6. Knapp, D. The Thessaloniki declaration: A wake-up call for environmental education? *J. Environ. Educ.* **2000**, *31*, 32–39.
7. Nagra, V.; Singh, S. Environmental education awareness among senior secondary school teachers. *Int. J. Behav. Soc. Mov. Sci.* **2013**, *2*, 242–251.
8. Sonowal, C.J. Environmental education in schools: The Indian scenario. *J. Hum. Ecol.* **2009**, *28*, 15–36.
9. Liarakou, G.; Gavrilakis, C.; Flouri, E. Secondary school teachers' knowledge and attitudes towards renewable energy sources. *J. Sci. Educ. Technol.* **2009**, *18*, 120–129.
10. International Energy Agency (IEA). *Energy for All. Financing Access for the Poor*; International Energy Agency: Paris, France, 2011.
11. Shulman, L.S. Those who understand: Knowledge growth in teaching. *Educ. Res.* **1986**, *15*, 4–14.
12. Hynes, M.M. Middle-school teachers' understanding and teaching of the engineering design process: A look at subject matter and pedagogical content knowledge. *Int. J. Technol. Des. Educ.* **2012**, *22*, 345–360.
13. Mäntylä, T.; Nousiainen, M. Consolidating pre-service physics teachers' subject matter knowledge using didactical reconstructions. *Sci. Educ.* **2013**, doi:10.1007/s11191-013-9657-7.
14. Yip, D.Y.; Chung, C.M.; Mak, S.Y. The subject matter knowledge in physics related topics of Hong Kong junior secondary science teachers. *J. Sci. Educ. Technol.* **1998**, *7*, 319–328.
15. Cheney, G.R.; Ruzzy, B.B.; Muralidharan, K. *A Profile of the Indian Education System;* Paper Prepared for the New Commission on the Skills of the American Workforce; National Centre on Education and the Economy: Washington, DC, USA, 2005; p. 28.
16. Yadav, S.K. *National Study on Ten Year School Curriculum Implementation*; National Council of Educational Research and Training, Department of Teacher Education: New Delhi, India, 2013; p. 182.

17. National Council of Educational Research and Training. *Position Paper 1.6: National Focus Group on Habitat and Learning*; National Council of Educational Research and Training, Department of Teacher Education: New Delhi, India, 2006; p.38.
18. National Council of Educational Research and Training. *Seventh All India School Educational Survey—Provisional Statistics*; National Council of Educational Research and Training, Department of Teacher Education: New Delhi, India, 2002; p 210.
19. National Council of Educational Research and Training. *Position Paper 1.1: National Focus Group on Teaching of Science*; National Council of Educational Research and Training, Department of Teacher Education: New Delhi, India, 2006; p 38.
20. Gayford, C. Biodiversity education: A teacher's perspective. *Environ. Educ. Res.* **2010**, *6*, 347–361.
21. Lindemann-Matthies, P. Investigating nature on the way to school: Responses to an educational programme by teachers and their pupils. *Int. J. Sci. Educ.* **2007**, *28*, 895–918.
22. Summers, M.; Kruger, C.; Childs, A.; Mant, J. Primary school teachers' understanding of environmental issues: An interview study. *Environ. Educ. Res.* **2010**, *6*, 293–312.
23. Diakidoy, I.A.N.; Iordanou, K. Preservice teachers' and teachers' conceptions of energy and their ability to predict pupils' level of understanding. *Eur. J. Psychol. Educ.* **2003**, *18*, 357–368.
24. Ifegbesan, A. Waste management awareness, knowledge, and practices of secondary school teachers in Ogun state, Nigeria—Implications for teacher education. *J. Sol. Waste. Technol. Manag.* **2011**, *37*, 221–234.
25. Kidman, G. Attitudes and interests towards biotechnology: The mismatch between students and teachers. *Eurasia J. Math. Sci. Technol. Educ.* **2009**, *5*, 135–143.
26. Said, A.M.; Ahmadun, F.-R.; Paim, L.H.; Masud, J. Environmental concerns, knowledge and practices gap among Malaysian teachers. *Int. J. Sustain. High. Educ.* **2003**, *4*, 305–313.
27. Trumper, R. The need for change in elementary school teacher training: The case of the energy concept as an example. *Educ. Res.* **1997**, *39*, 157–174.
28. Saglam-Arslan, A. Cross-grade comparison of students' understanding of energy concepts. *J. Sci. Educ. Technol.* **2010**, *19*, 303–313.
29. Halder, P.; Havu-Nuutinen, S.; Pietarinen, J.; Pelkonen, P. Bio-energy and youth: Analyzing the role of school, home, and media from the future policy perspectives. *Appl. Energy* **2011**, *88*, 1233–1240.
30. Halder, P.; Prokop, P.; Chang, C.-Y.; Usak, M.; Pietarinen, J.; Havu-Nuutinen, S.; Pelkonen, P.; Cakir, M. International survey on bioenergy knowledge, perceptions and attitudes among young citizens. *Bioenergy Res.* **2012**, *5*, 247–261.
31. Halder, P.; Havu-Nuutinen, S.; Pietarinen, J.; Pelkonen, P.; Prokop, P.; Chang, C-Y.; Usak, M. Knowledge, perceptions, and attitudes as determinants of youth's intentions to use bioenergy—A cross-national perspective. *Int. J. Green Energy* **2013**, *10*, 797–813.
32. Zyadin, A.; Puhakka, A.; Ahponen, P.; Pelkonen, P. Secondary school teachers' knowledge, perceptions, and attitudes toward renewable energy in Jordan. *Renew. Energy* **2014**, *62*, 341–348.
33. Çelikler, D. Awareness about renewable energy of pre-service science teachers in Turkey. *Renew. Energy* **2009**, *60*, 343–348.
34. Kainth, G.S. Environmental awareness among school teachers. *IUP J. Environ. Econ.* **2009**, *7*, 34–50.

35. Evans, J.M.; Fletcher, R.J., Jr.; Alavalapati, J.; Calabria, J.; Geller, D.; Smith, A.L.; Lal, P.; Upadhyay, T.; Acevedo, M.; Vasudev, D. *Forestry Bioenergy in the Southeast United States: Implications for Wildlife Habitat and Biodiversity*; National Wildlife Federation: Merrifield, VA, USA, 2013; p. 275.
36. Fargione, J.; Plevin, R.J.; Hill, J. The ecological impact of biofuels. *Annu. Rev. Ecol. Evol. Syst.* **2010**, *41*, 351–377.
37. Stern, P.C.; Dietz, T.; Kalof, L. Value orientations, gender, and environmental concern. *Environ. Behav.* **1993**, *25*, 322–348.
38. Alibeli, M.A.; White, N.R. The structure of environmental concern. *Int. J. Bus. Soc. Sci.* **2011**, *2*, 1–8.
39. Ribeiro, F.; Ferreira, P.; Araújo, M.; Braga, A.C. Public opinion on renewable energy technologies in Portugal. *Energy* **2014**, *69*, 39–50.
40. Zelezny, L.C.; Chua, P.-P.; Aldrich, C. Elaborating on gender differences in environmentalism. *J. Soc. Issues* **2000**, *56*, 443–457.
41. Karlstrøm, H.; Ryghaug, M. Public attitudes towards renewable energy technologies in Norway. The role of party preferences. *Energy Policy* **2014**, *67*, 656–663.