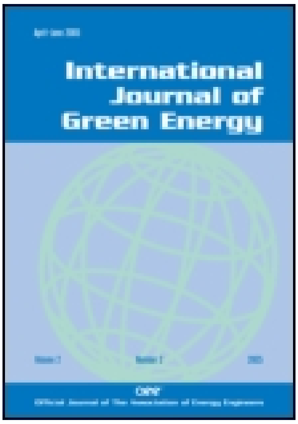

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Knowledge, Perceptions, and Attitudes as Determinants of Youths' Intentions to Use Bioenergy—A Cross-National Perspective

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KNOWLEDGE, PERCEPTIONS, AND ATTITUDES AS DETERMINANTS OF YOUTHS' INTENTIONS TO USE BIOENERGY—A CROSS-NATIONAL PERSPECTIVE

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Development of modern bioenergy sector is an important step toward meeting societal demand for reducing CO_2 emissions and supplying eco-friendly energy. Young students are the future decision-makers and they will play an important role toward transforming the present fossil fuel driven society into a renewable energy based society. The study aimed to explain young students' intentions to use bioenergy by considering their knowledge perceptions, and attitudes related to bioenergy in Finland, Taiwan, Turkey, and Slovakia. Data for this study came from a previous survey in these countries among 15-year-old 1903 school students. This study with the help of Principal Component Analysis revealed the dimensions of the students' perceptions of and attitudes related to bioenergy. One of the dimensions "pro-environmental intention" was used as the dependent variable in the Multiple Regression Analyses. Results indicated that students' intentions to use bioenergy were mostly guided by their perceptions of the socio-environmental aspects related to bioenergy. Individual level decision-making such as communicating and learning more about bioenergy was also important; however, with a low impact value. Results also suggested that the "critical–environmental" dimension had only minor influence on the students' intentions to use bioenergy. Students' level of bioenergy-knowledge especially those with a relatively higher level appeared to have a strong impact on their intentions to use bioenergy. Young students should be facilitated to become aware of bioenergy in order to influence their intentions to use it in the future.

Keywords: ***Bioenergy; Perceptions; Attitudes; Knowledge; Intentions to use; Youth***

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INTRODUCTION

The threat of climate change has been in the focus of energy related discussions for long time (IEA-ETP 2010). Climate change and future energy needs are two intertwined and urgent policy challenges for which solutions need to be developed and implemented urgently in countries throughout the world (Bauen et al. 2009; Corner et al. 2011). However, uncertainties loom large over the energy future of our societies (IEA-WEO 2010). Depending on the scenario, world's energy consumption is projected to increase by 36% by 2035 (IEA-WEO 2010). If traditional energy sources are used to meet the increased demand this will further exacerbate climate change; thus, new sources of environmentally friendly energy are sought. In this context, renewable energies are expected to play a central role in moving the world to a more secure, reliable, and sustainable energy future (IEA-WEO 2010).

Renewable energies can address the rising demand for energy, concerns for environmental protection, and energy security (Haar and Theyel 2006). Among the renewable energies, traditional way of burning wood for producing heat has been in the practice for millennia. The trend is still going on and today bioenergy meets about 10% of the world's demand for primary energy of which the share of woody biomass alone is about 87% (IEA 2010). However, presently technologies that are more sophisticated are in place to convert woody biomass to bioelectricity, biofuels, and biogas (Buchholz, Volk, and Luzadis 2007; Demirbas, Balat, and Balat 2009; Stidham and Simon-Brown 2011).

The development of modern bioenergy sector is poised to take a great leap due to strong policy support by governments in many developed and developing countries (Boons and Mendoza 2010; Schubert and Blasch 2010). The greatest societal and ecological benefit will come from the development of the bioenergy sector through sustainable pathways that consider social, ecological, and economic factors. This requires an innovative, informed, and motivated citizenry (Richard 2010). The public needs to be informed and confident that bioenergy is environmentally and socially beneficial and does not create significant negative environmental and social trade-offs (Bauen et al. 2009). If achieved, social acceptance of bioenergy can help to realize a better condition for growth of its market share (Magar et al. 2011). Social acceptance for bioenergy projects can be characterized as support for such projects from policy makers and experts; public availability of information and a positive view about a new technology in the society; and public willingness to adopt the application of a new technology (Alasti 2011).

The public, especially the youth, are integral elements of the initial renewable energy implementation process (Zyadin et al. 2012). It has been found that energy awareness and values are generally formulated during childhood (Zografakis, Menegaki, and Tsagarakis 2008). Recent trends also show that energy consumption has increased among young students and at the same time, their concerns over the environmental impacts of their energy-intensive lifestyles have grown (Intelligent Energy Europe 2009). Despite understanding the role of young students in sustainable development including energy related issues, current research initiatives are not adequate to investigate their behavioral intentions to the future renewable energy systems especially those based on biomass. The present study from this perspective focuses on young students' intentions to use bioenergy from a cross-national perspective.

CONCEPTUAL FRAMEWORK

Knowledge, Perceptions, Attitudes, Behavior Intentions, and Behaviors

The concepts of and relationships among knowledge, perceptions, attitudes, behavioral intentions, and behaviors in the context of social and environmental issues are much studied and debated topics. There is a wealth of research available in this social–psychological arena from the past five decades and new concepts are evolving. The present article briefly explains these concepts in the following discussions and links them with young students and bioenergy in the subsequent section. The concept of knowledge has appeared as a construct formed by interlinking numerous intellectual components comprising of various theories and hypotheses (Spuzic, Xing, and Abhary 2008; Abhary, Adriansen, and Begovac 2009). Davenport and Prusak (1998) defined knowledge as a "fluid mix of framed experience, values, contextual information, and expert insights." Fryxell and Lo (2003) have proposed "environmental knowledge" as knowledge of facts, concepts, and relationships concerning environment and its major ecosystems. A subtle difference between knowledge and information appears as Nonaka (1994) suggests that knowledge is generally created and organized by the flow of messages that constitutes information.

On defining perceptions, White (1988) describes them as initial thoughts of a phenomenon and perceptions along with attitudes are crucial components of learning and have a causal relationship with it. Various authors have debated the notion that perceptions imply consciousness and they have argued that perceptions can even occur when there is no awareness of perceiving (Merikle, Smilek, and Eastwood 2001). Furthermore, while elaborating perceptions, Kohler and Mathieu (1993) suggest that individuals' characteristics and perceptions of the environment may influence individuals' behavior directly. There is also an argument, which supports perceptions as a determinant of behavioral intention particulalry in the case of new technologies (Liaw and Huang 2003). Unlike perceptions, attitude is the degree to which one evaluates the behavior favorably or unfavorably (Gagné 2009). Attitudes have also been conceptualized as an organization of consistent response toward some social object (Liska 1974) and it is generally considered that attitudes are often linked to emotional reactions and willingness to do something (White 1988). In the context of "willingness to do something," two additional constructs emerge: behavioral intentions or intentions to act and pro-environmental behavior.

Behavior can simply be understood as a person's action or reaction to a situation or stimulus. Behavior can be measured in terms of behavior intentions, in terms of self-report of past behavior, and in terms of observation of actual overt behavior (Liska 1974). However, the current study only concentrates on the measure of behavioral intention while dealing with youths' knowledge, perceptions, and attitudes related to bioenergy as the other two measures are beyond the scope of the study. Though some studies show that attitudes act as predictors of behaviors, a large range of research still deals with better understanding of the attitude-behavior link particulalry the attitude-behavior inconsistency (Ajzen and Fishbein 2005). In this context, the *Theory of planned behavior* (TPB: Ajzen 1991) rests on the conclusion that an intention to perform a behavior in question is an immediate antecedent of an overt behavior. Intentions are assumed to capture the motivational factors that influence a behavior and strengthen a person's intentions, the higher the likelihood that the person will perform the behavior (Ajzen 1991). However, this is not the case always. Though previous studies suggest that when behavioral intentions are appropriately measured they explain a large proportion of variance in actual behavior, yet low intentions-behavior correlations have emerged in many previous studies (Ajzen and Fishbein 2005).

Notwithstanding that the TPB has been regarded as a powerful model to predict and explain individuals' social behaviors, the utility of the model to achieve long-range predictions have been questioned by Ajzen (1985) and recently a new model within the framework of the TPB, "continuation intentions" in predicting social behavior has been introduced by Chatzisarantis et al. (2004). In addition to the TPB, to understand people's conservation behavior by taking into account their moral and other altruistic considerations researchers often use the *Value-belief-norm* (VBN) theory introduced by Stern et al. (1999). The VBN theory proposes that that environmental behavior results from personal norms, i.e., a feeling of moral obligation to act pro-environmentally (Steg, Dreijerink, and Abrahamse 2005). Recently, Kaiser, Hübner and Bogner (2006) have shown that both the TPB and VBN models could produce remarkable explanatory power to predict people's conservation behavior and TPB appears to have more explanatory power compared to the VBN model. However, the results from that study appear to be less conclusive because of strong gender bias toward females among the respondents and it needs further evidences to rank and compare the explanatory power of the two models.

The above studies provide a range of conceptual insights into the realm of these social–psychological constructs; however, they were not cross-national and none of them included school students to explain their intentions to act in energy related issues. It can be said that positive intentions to act come from positive attitudes and in environmental matters, it often indicates an individual's intentions to pay more for a green product or services (Han, Hsu, and Lee 2009). An individual's attitudes to ecological behavior involve perceived importance of environmental awareness, severity of environmental problems, and the level of responsibility of cooperation (McCarty and Shrum 1994; Roberts 1996; Laroche, Bergeron, and Barbaro-Forleo 2001). Various studies also indicate that ecologically aware individuals have positive attitudes to pay a high price for ecological products and adopt ecologically responsible behaviors (Laroche, Bergeron, and Barbaro-Forleo 2001; Manaktola and Jauhari 2007; Han, Hsu, and Lee 2009).

Results from the previous studies have shown that the relation between pro-environmental intentions and behaviors among individuals is rather complex than straightforward by nature and it is influenced by several factors simultaneously (Hines, Hungerford, and Tomera 1987). The relationships between the different cognitive terms used in the study have been shown in Figure 1. However, it should be taken into account

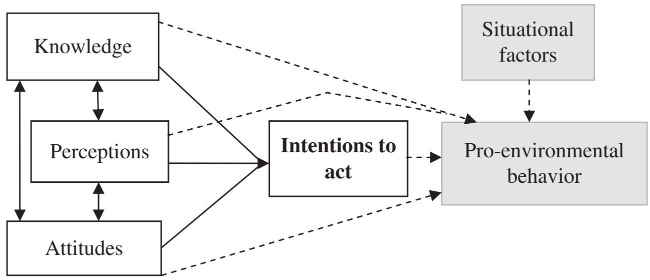

Figure 1 Simplified relationships between the cognitive terms used in the study. Terms within the dark boxes and relationships shown with the dashed arrows were not studied in the present study.

that although the diagram illustrates a flow from left to right in the development of intentions to act and pro-environmental behavior, the model is dynamic and each term interacts with each other. It appears to involve a number of variables other than the ones presented in the diagram, which exert considerable influence on the model outcome (Hines, Hungerford, and Tomera 1987). For example, in the original behavioral model situational factors were defined as economic constraints, social pressure, and opportunities to choose different actions that appeared to affect individuals' pro-environmental behaviors. Similarly, there could be different dimensions of perceptions and attitudes that have different influences on individuals' intentions to act in environmental matters.

In addition to the above-mentioned variables, the effect of age appears to be an important factor in environmental decision-making process. For example, older people appear to be more frequently engaged in purchasing environmentally friendly products than younger people (Sandahl and Robertson 1989; Vining and Ebreo 1990; Roberts 1996). However, it has also appeared that young people tend to have more environmentally positive attitudes than old people (de Pauw and Petegem 2010). Many cross-national studies have concentrated on the issue of culture and values, which seem to play a significant role in influencing public attitudes including behaviors (Franke and Nadler 2008). In this regard, Prokop et al. (2007) found a significant relationship of knowledge, perceptions and attitudes among young Slovakian students related to biotechnology. On the other hand, Dawson and Schibeci (2003) have indicated that an increase in knowledge of a new technology cannot guaranty a change among youths' intentions to use that technology. Previous research has also found that though increased awareness and knowledge are important, they have limited influence on attitudes and behaviors of the public (Douglas et al. 1998).

Energy Use and the Social–Psychological Constructs

Public attitudes are crucial to the choice of our energy future (Owens and Driffill 2008) and an individual's attitude is determined by his/her beliefs in the attitude-object (Ajzen 1991). It has been found that in energy related matters the VBN theory is successful in explaining judgments of acceptability of energy policies among households (Steg, Dreijerink, and Abrahamse 2005). However, in reality there is a gap between people's positive attitudes to renewable energies and their intentions to pay more for them. Evidences found from Sweden show that though a higher number of individuals expressed positive intentions to pay for green electricity from renewables, only 1% made voluntary purchase of green electricity by paying a higher price for it (Hansla et al. 2008). As technologies for modern bioenergy are new, public knowledge is low as shown in previous studies from various parts of the world (Segon et al. 2004; Askew 2006; Eurobarometer 2007; Adelle and Withana 2008; EECA 2008; Halder et al. 2010). In this context, it is important to understand that an individual's positive perceptions of and attitudes to a technology can be regarded as an intention to use that technology and actively support its development in the society (Hansla et al. 2008).

Cross-national studies on evaluating bioenergy through the lens of school students are not many to date. In this respect, Halder et al. (2012) conducted a study among 15-year-old school students in Finland, Taiwan, Turkey, and Slovakia to explore their knowledge, perceptions, and attitudes related to bioenergy. The findings of the study indicated young students' low level of bioenergy-knowledge and their critical perceptions of forest-based bioenergy. However, the students demonstrated positive intentions to use bioenergy in the future as well as positive attitudes to gain more knowledge of bioenergy. Nevertheless, there were differences among the countries in terms of the students' knowledge, perceptions, and attitudes related to bioenergy. However, the study did not examine how the students' intentions to use bioenergy could be explained by considering their knowledge, perceptions, and attitude to learn more on bioenergy. The study was able to reveal three key dimensions of the students' overall perceptions of and attitudes to bioenergy. Nevertheless, it did not analyze the perceptions and attitudes separately to explore if they contained a dimension among the attitudinal items that would reflect the students' intentions to use bioenergy. Since a number of studies have discussed the effects of an improved knowledge, perceptions, and attitudes related to a technology on individuals' intentions to use that technology (Dawson and Schibeci 2003; Liaw and Huang 2003; Hansla et al. 2008; Han, Hsu, and Lee 2009). It is particularly relevant to understand the role of these social–psychological determinants in a cross-national setting to explain students' intentions to use bioenegy. Based on this understanding, decision makers will be able to formulate strategies to improve public knowledge, perceptions, attitudes, and behaviors related to bioenergy particularly among young students.

Aims of the Study

The main aims of the study are: (1) to explain young students' intentions to use bioenergy by considering their knowledge, perceptions, and attitudes related to bioenergy from a cross-national perspective; (2) to determine the key components of the students' perceptions of and attitudes to bioenergy that are most important in Finland, Taiwan, Turkey, and Slovakia to explain their intentions to use bioenergy; and (3) to explore the energy and societal implications of the study findings.

METHODS

The current study builds on the data from the previous cross-national study by Halder et al. (2012), which investigated 15-year-old school students' ($n = 1903$) knowledge, perceptions, and attitudes related to bioenergy in Finland, Taiwan, Turkey, and Slovakia. These countries were selected based on their variations in the field of bioenergy development and socio-economic contexts. Although these countries belonged to a previous research network that facilitated to collect data within a short period, the variations in socio-economic contexts in these countries contributed to generate the required data to fulfill the objectives of the study (Halder et al. 2011).

In each country, the researchers analyzed the national course curriculum of school education to determine the comparable target groups among the students for the study. A pilot test was conducted in each country with an initial form of the questionnaire translated into the local languages and distributed among students in a school. The pilot test results and feedbacks from the students and suggestions by experts helped to improve the content validity of the final version of the questionnaire. The collection of the final data was through a questionnaire survey from March to July 2009. Student participation was voluntary and anonymous and they were not offered any incentives for their participation in the survey. The survey questionnaires administered among the students were the translated versions in the local languages of each country and the researchers did the translation back into English for the analysis. Experts for maintaining a linguistically equivalent translation later validated them. The quantitative analysis was conducted by using SPSS 17.0 programme.

A detailed discussion on the selection of the countries, instrument design, data collection, and reliability analysis of the instrument can be found in Halder et al. (2012).

In this study, a Principal Component Analysis (PCA) was conducted with the perceptions and attitudes related items separately in order to reveal their internal structures and to find out whether one of them would indicate students' intentions to use bioenergy (Table 1). The items with dimension loading less than 0.50 were left out from the analysis. The PCA results revealed two key dimensions (Eigen value >1) among the perceptions related items such as *socio-environmental* dimension and *critical–environmental* dimension explaining 67% of the variations in the data related to students' perceptions of bioenergy. The *socio-environmental* dimension consisted of items that reflected the students' perceptions of the environmental aspects of bioenergy (i.e., mitigating global warming problem) as well as the societal aspects such as replacement of fossil fuels by the use of bioenergy and expected contribution from policy makers to develop bioenergy research and development in the society. The *critical–environmental* dimension consisted of the items that denoted the environmental and sustainability dimensions of bioenergy; however, the criticality in this context had been interpreted as the students' critical perceptions of the environmental and sustainability aspects of bioenergy.

Two principal components (Eigen value >1) also emerged from the attitudes items. The *learning* dimension consisted of the items that denoted students' attitudes to gain more knowledge of bioenergy by various means such as visiting a bioenergy plant and studying and discussing with teachers, parents, and classmates. On the other hand, the *pro-environmental intention* dimension indicated students' intentions to use bioenergy. These two components altogether explained 74% of the variations in the data related to the students' attitudes to learn and intentions to use bioenergy.

Table 1 Results of the PCA from Students' Perceptions of and Attitudes to Bioenergy[a,b,c,d]

Key dimensions of students' perceptions of and attitudes to bioenergy	Loadings on dimensions	
Perceptions		
I. *Socio-environmental* ($\alpha = 0.78$)		
Increased use of bioenergy can mitigate the global warming problems	0.853	
Politicians should support research and development in bioenergy	0.836	
Bioenergy can replace the use of oil and gas in the future	0.805	
II. *Critical–environmental* ($\alpha = 0.70$)		
Production of energy from wood is environmentally friendly		0.811
Cutting of trees for energy production is justified		0.792
Production of bioenergy from forests is sustainable globally		0.754
Attitudes		
III. *Learning* ($\alpha = 0.87$)		
I would like to discuss more about bioenergy with my parents	0.882	
I would like to discuss more about bioenergy with my classmates	0.867	
I would like to discuss more about bioenergy with my teachers	0.861	
I would like to study more about bioenergy in the future	0.743	
I would like to visit a bioenergy plant in my region	0.644	
IV. *Pro-environmental intention* ($\alpha = 0.79$)		
I would like to drive a car in the future that runs on biofuel		0.892
I would like to use bioenergy at home in the future		0.887

[a]Rotated components using Varimax; [b]Rotation converged in three iterations; [c]Kaiser–Myer–Olkin Measure of Sampling Adequacy > 0.70; [d]Bartlett's Test of Sphericity = <0.001.

The reliability of the four key components was evaluated following Briggs and Cheek (1986) recommendations for both internal consistencies and homogeneity. Cronbach's alpha value, equal to or higher than 0.70, denotes an acceptable level of internal consistencies for basic research (Nunnally 1978; Bland and Altman 1997), whereas mean inter-item correlations (MIC) ranging from 0.20 to 0.40 indicate as the optimum level (Briggs and Cheek 1986). However, Cronbach's alpha value, lower than 0.70, and MIC values, both lower and higher than the 0.20–0.40 range, have been reported in a previous environmental psychology-related study and is generally accepted with large data (Milfont and Gouveia 2006). The reliability check of the *socio-environmental*, *critical–environmental*, and *learning* and *pro-environmental intention* dimensions showed satisfactory level of internal consistencies as α-values were 0.78 (MIC = .55), 0.70 (MIC = .44), 0.87 (MIC = .58), and 0.79 (MIC = .67), respectively. Both the reliability checks and homogeneity assessments confirmed the internal consistencies of the data for the multiple regression analysis. Data analysis was conducted by the SPSS 17 statistical software package. However, as the MIC values were on the higher side the results must be interpreted with caution.

RESULTS

Correlations between the Key Dimensions of Students' Perceptions of and Attitudes to Bioenergy

Correlation analysis indicated that there were significant positive relationships (from strong to weak) between the dimensions *socio-environmental* and *pro-environmental intention; learning* and *pro-environmental intention*; and *learning* and *socio-environmental* (Table 2). On the other hand, there were significantly weak and negative relationships between *critical–environmental* and *pro-environmental intention;* and *critical–environmental* and *socio-environmental*. No such strong relationship appeared between the dimensions *learning* and *critical–environmental*. The Skewness and Kurtosis checks did not reveal any major skew in the key components of students' perceptions of and attitudes to bioenergy. It became apparent from the correlation results that the students' intentions to use bioenergy were most strongly related to the *socio-environmental* dimension. However, the students' criticality of forest-based bioenergy production (*critical–environmental*) and their interests to learn more on bioenergy (*learning*) did not appear to have such strong relationships with their intentions to use bioenergy.

Table 2 Spearman's Correlation Coefficients for the Relationship between the Key Dimensions of Students' Perceptions of and Attitudes to Bioenergy

Measures	*Pro-environmental intention*	*Socio-environmental*	*Critical–environmental*	*Learning*
Pro-environmental intention	1.00			
Socio-environmental	0.68***	1.00		
Critical–environmental	−0.26***	−0.25***	1.00	
Learning	0.24***	0.13***	0.01	1.00
Mean	6.24	9.04	7.70	16.64
SD	2.13	2.94	2.64	4.29
Skewness	−0.24	−0.16	0.25	0.01
Kurtosis	−0.55	−0.62	−0.30	0.14

***$p < .001$, Two-tailed.

Multiple Regression Analysis to Explain Students' Intentions to Use Bioenergy

Students' intentions to use bioenergy were explained by conducting a series of multiple regression analyses. The independent variables (IDs) were *socio-environmental*, *critical–environmental*, and *learning* dimensions while the dependent variable was *pro-environmental intention*. The results indicated that Tolerance coefficients were higher than 0.20 and variance-inflation factor coefficients were lower than 4.0, denoting the absence of multivariate multicollinearity in the data (Garson 2003). The final model produced a significant equation ($F_{3,\,1875} = 694.81$; $p < .001$; Adj. $R^2 = 0.53$). The Dublin-Watson statistic showed a value of 1.95, which indicated that the independent errors in the model were tenable. All the three IDs were included in the final model and they were as follows: *socio-environmental* ($\beta = 0.67$; t-value $= 39.92$; $p < .001$), *learning* ($\beta = 0.16$; t-value $=$ 9.83; $p < .001$), and *critical–environmental* ($\beta = -0.10$; $t = -5.88$; $p < .001$) (Table 3).

The results indicated that the IDs s*ocio-environmental* and *learning* had positive while *critical–environmental* had negative relationships with the criterion variable *pro-environmental intention*. From the magnitude of the t-statistics, it appeared that the ID s*ocio-environmental* had much larger impact than the *learning* did on the model outcomes.

Effects of Students' Level of Bioenergy-Knowledge on their Pro-Environmental Intention to Use Bioenergy

Halder et al. (2012) in their study revealed that the majority of the students (76%) had "low" level of bioenergy-knowledge, 20% had "medium," while only 4% had "high" level of bioenergy-knowledge. However, in this study students' level of bioenergy-knowledge was re-coded into two groups to be able to use it as a grouping variable since in two groups the differences were possible to compare. One of them comprised of students with "low" level of bioenergy-knowledge while the other comprised of students with "medium

Table 3 Multiple Regression Analysis of P*ro-Environmental Intention* to Use Bioenergy with S*ocio-Environmental*, L*earning*, and C*ritical–Environmental* as IDs

IDs entered by step	b	S.E.b	β
Step 1			
Constant	1.53	0.11	
Socio-environmental	0.52	0.01	0.70***
Step 2			
Constant	0.44	0.16	
Socio-environmental	0.50	0.01	0.68***
Learning	0.07	0.01	0.15***
Step 3			
Constant	1.12	0.20	
Socio-environmental	0.49	0.01	0.67***
Learning	0.08	0.01	0.16***
Critical–environmental	−0.08	0.01	−0.09***

$R^2 = 0.49$ for Step 1; $\Delta R^2 = 0.01$ for Step 3 (Sig. F change $< .001$); β is the standardized regression coefficients; b is the unstandardized regression coefficients; S.E. b is the standard error of the unstandardized regression coefficients;

$^{***}p < .001$.

Table 4 Multiple Regression Analysis Showing the Effects of Students' Level of Bioenergy-Knowledge on Their P*ro-Environmental Intention* to Use Bioenergy

IDs entered by step	Students with "low" level of bioenergy-knowledge			Students with "medium and high" level of bioenergy-knowledge		
	b	S.E. *b*	β	*b*	S.E. *b*	β
Step 1						
Constant	1.65	0.17		0.83	0.26	
Socio-environmental	0.50	0.02	0.72***	0.60	0.03	0.79***
Step 2						
Constant	0.84	0.25		−0.07	0.41	
Socio-environmental	0.49	0.02	0.70***	0.57	0.03	0.75***
Learning	0.06	0.01	0.12***	0.07	0.02	0.11**
Step 3						
Constant	1.64	0.31		0.68	0.55	
Socio-environmental	0.47	0.02	0.67***	0.55	0.03	0.72***
Learning	0.06	0.01	0.11***	0.07	0.02	0.11**
Critical–environmental	−0.09	0.02	−0.11***	−0.07	0.03	−0.09*

β is the standardized regression coefficients; *b* is the unstandardized regression coefficients; S.E. *b* is the standard error of the unstandardized regression coefficients;

***p < .001; **p < .01; *p < .05.

and high" level of bioenergy-knowledge. A multiple regression analysis was performed to explain students' intentions to use bioenergy by controlling for the students with "low" level of bioenergy-knowledge (Table 4). The final model produced a significant equation ($F_{3, 766} = 295.73$; $p < .001$; Adj. $R^2 = 0.53$) and all the IDs were included in the final model.

A second multiple regression analysis was performed by controlling for the students with "medium and high" level of bioenergy-knowledge. It also produced a significant equation in the final step ($F_{3, 241} = 141.65$; $p < .001$; Adj. $R^2 = 0.63$) and all the IDs remained in the final model. It appeared that the explanation rate of the second model increased as it could explain about 63% of the variation in the dependent variable *pro-environmental intention* compared to the 53% in the other model. However, both the models showed that the ID s*ocio-environmental* had much stronger impact on the model outcomes compared to the other IDs *learning* and *critical–environmental*.

Country Wise Multiple Regression Analyses to Explain Students' Pro-Environmental Intention to Use Bioenergy

A series of multiple regression analyses were performed with the data from each country to reveal the explanatory power of the IDs on the dependent variable *pro-environmental intention* (Table 5). Cronbach's alpha and homogeneity assessments of the model constructs showed acceptable level of internal consistencies in each country. The final models in each country produced significant equations: Finland ($F_{2, 485} = 144.69$; $p < .001$; Adj. $R^2 = 0.37$); Taiwan ($F_{3, 882} = 142.68$; $p < .001$; Adj. $R^2 = 0.32$); Turkey ($F_{1, 337} = 254.50$; $p < .001$; Adj. $R^2 = 0.43$); and Slovakia ($F_{2, 163} = 20.85$; $p < .001$; Adj. $R^2 = 0.19$).

The results showed that the ID *socio-environmental* had significant impacts on the model in all the four countries, whereas the ID *learning* had such impacts in Finland,

Table 5 Coefficients and *t*-Values of the Predictors on the Dependent Variable *Intended User* Bioenergy Across the Four Countries

Country	IDs in the final model	β	*t*-value	Excluded IDs	β	*t*-value
Finland	*Socio-environmental*	0.51***	13.48	*Critical–environmental*	−0.03	−0.78
	Learning	0.20***	5.25			
Taiwan	*Learning*	0.37***	13.34			
	Socio-environmental	0.38***	13.31			
	Critical–environmental	−0.07	−2.54			
Turkey	*Socio-environmental*	0.55***	15.96	*Critical–environmental*	0.01	0.16
				Learning	0.01	0.27
Slovakia	*Socio-environmental*	0.29***	4.09	*Critical–environmental*	0.08	1.19
	Learning	0.29***	4.01			

All Beta (β) values are standardized regression coefficients with associated *t*-statistics and probability values; ***p < .001.

Taiwan, and Slovakia. The ID c*ritical–environmental* was only included in the model in Taiwan although it showed a negative relationship with the dependent variable *pro-environmental intention*. Criticality was insignificant to determine students' intentions to use bioenergy in all the countries though in Taiwan it affected slightly.

DISCUSSION

Bioenergy is expected to play a significant role in the global energy mix of the next decades, transforming the current fossil fuel-based economy into a low-carbon energy economy (Beringer, Lucht, and Schaphoff 2011). Therefore, the future bioenergy systems should ensure long-term sustainability of this field by taking into account the environmental, economic, and social dimensions (Londo and Deurwaarder 2007). However, there is a significant research gap in exploring the role and social acceptance of bioenergy while implementing bioenergy projects around the world (McCormick 2010). Current research on this topic is limited and it becomes rare in the context of evaluating young students' awareness of bioenergy from a cross-national perspective.

The present study aimed to increase our understanding of the formation of young students' intentions to use bioenergy by considering the effects of their knowledge, perceptions, and attitudes related to bioenergy from the data from Finland, Taiwan, Turkey, and Slovakia. In order to do that, four key dimensions were extracted from the data related to students' perceptions of and attitudes to bioenergy. One of the dimensions, *pro-environmental intention*, denoting students' intentions to use bioenergy was treated as a criterion variable in the multiple regression analyses. The other three dimensions—*socio-environmental,* c*ritical–environmental* and *learning*—were treated as determinants. The findings indicated that *socio-environmental* emerged as the most significant determinant of the students' intentions to use bioenergy along with the other determinant *learning* although the latter showed a lower explanatory power than the former. However, the other determinant, c*ritical–environmental*, showed a negative relationship with the students' intentions to use bioenergy. This negative relationship could stem from the finding by the study by Halder et al. (2012) that showed that the students with strong critical perceptions of bioenergy were less intended to use bioenergy in the future. Students' level of bioenergy-knowledge especially those with a high level of such knowedge appeared to have a strong impact on the relationship between the model constructs as it explained substantially the variation in students' intentions to use bioenergy.

There were more similarities than differences that emerged from each country level analysis to explain the students' intentions to use bioenergy by considering their perceptions of and attitudes to gain and learn more about bioenergy. The determinant *socio-environmental* showed significant positive impact on the model outcomes in all the four countries. Overall, the study findings indicated the students' intentions to use bioenergy could be better explained by considering their perceptions of the social and environmental aspects related to bioenergy. Although the students' attitudes to learn more about bioenergy showed both positive and significant impacts on the model, that relationship was not very strong. The results suggested that though the students were critical of forest-based bioenergy production, it did not have strong impact on their intentions to use bioenergy. One of the important findings from the study is the emergence of the determinant *socio-environmental* and its powerful role in explaining the students' intentions to use bioenergy. This component consists of items that represent both social and environmental aspects of bioenergy. These aspects of bioenergy are global and much discussed in media and other forums. Therefore, it appears that the way students perceive these particular aspects related to bioenergy can strongly determine their intentions to use bioenergy. On the other hand, students' attitudes to learn more about bioenergy and providing that opportunity depend on local circumstances such as schools' environment, motivated teachers, interested and educated parents, and demonstration sites, e.g., a local bioenergy installation. Therefore, there is a need for more discussions of bioenergy both at global and local level while local level actions such as providing students education and information related to bioenergy and involving parents in bioenergy related discussions can motivate them to use bioenergy.

Further evidences from this study suggested country-wise variations in the determinants to explain the students' intentions to use bioenergy. This has supported the existence of multidimensionality among the students' perceptions of and attitudes to bioenergy. The effects of the term in the model on R^2 were reasonable and it showed higher explanatory power than previous studies in explaining people's revealed intentions to pro-environmental behaviors. For example, private and public environmental protection behavior (Feng and Reisner 2011), public attitudes to underground carbon capture and storage (Sharp, Jaccard, and Keith 2009), and attitudinal ambivalence on pro-environmental behavioral intentions (Costarelli and Colloca 2004).

Energy and environmental issues are closely interwoven with global and national economic circumstances (Valkila and Saari 2010). Therefore, it is important to understand what people think and where attention should be focused to increase education and awareness raising of renewable energy (Ozil et al. 2008). This applies to bioenergy as well. The four countries involved in the study differ from each other both in terms of socio-economic and energy-environmental contexts. Among these countries, Finland is an advanced country in forest-based bioenergy production and utilization, whereas in Taiwan, Turkey, and Slovakia the energy reliance is on fossil fuels. In all these countries, their governments have taken strong policy measures toward developing renewable energy sources and bioenergy is one of them. Despite these variations in the national circumstances among these countries, the study suggested that young students' intentions to use bioenergy was mostly determined by their perceptions of the socio-environmental aspects related to bioenergy and their motivations to learn more on the topic. Thus, global discussions on the strengths of bioenergy are much needed and improved public perceptions of bioenergy seem to be significant for the individual behavioral decisions.

Taken together, these results suggest that policy makers and professionals working in the field of bioenergy should try to increase the positive image of bioenergy and facilitate students to become aware of bioenergy in order to influence their intentions to use bioenergy. Internationally more efforts are desirable to enhance public perceptions of bioenergy and create more opportunities to disseminate that information among young students. It is of greater societal benefits that if young students become aware of bioenergy, evaluate them critically, and have positive intentions to use it when they are sustainably produced.

Despite its strengths, the limitations in cross-national data are acknowledged, which perhaps suggest the direction for further research. Sampling is a problematic issue in cross-national studies and therefore the results are not free from possible biases, which affect any generalization of the results. The schools were selected based on their rural-urban locations in each country. However, rural and urban characteristics greatly vary across the countries and so do the characteristics of the respondents. Therefore, caution must be taken while considering the schools as a pure random sample and generalizing the results within a country and across the countries. Though the regression model from the pooled data showed a reasonable explanatory power, the country wise models were rather weak indicating a small effect size. Nevertheless, small effect sizes are rather common in psychology, social science oriented research, and smaller effect sizes can be practically important (Milfont and Gouveia 2006). In addition, the low explanatory powers in the country-wise models suggested that there might be key country specific socio-economic and demographic determinants of students' awareness of bioenergy that these models were not able to capture. In this study, students' intention to use bioenergy was measured using their knowledge, perceptions, and attitudes related to bioenergy. Though the study was aware of the model TPB (Ajzen 1991), it took into account additional constructs such as knowledge and perceptions while explaining the students' intentions to use bioenergy. Therefore, this new conceptual model needs further support before being generalized.

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