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YOUNG PEOPLE'S ACCEPTANCE OF BIOENERGY AND THE INFLUENCE OF ATTITUDE STRENGTH ON INFORMATION PROVISION

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Abstract

This study investigated the effects of using a standardized PowerPoint lecture to provide young people with nuanced information about bioenergy. The study's aim was to understand the relationship between knowledge and participants' perception of bioenergy, and the relationship of the latter to participants' attitude strength and intention to use and learn about bioenergy. Data were collected from 715 participants using a survey instrument that contained mainly Likert-scale questions. Data were then processed using partial least squares structural equation modelling. Results show that providing such information increases knowledge about bioenergy, but does relatively little to create a more positive perception of bioenergy. In turn, having a more positive view about bioenergy would lead to a higher intention to use bioenergy. Attitude strength was found to mediate the previous relationship and decreases the strength of the relationship between perception and intention to use. Results also show that the lecture weakly contributed to building attitude strength, rendering opinion change less likely in the future. We conclude that listening to a lecture on bioenergy slightly improves people's perception of bioenergy, makes it more likely that people maintain such a disposition, and translates into a slightly higher intention to use bioenergy.

Keywords: bioenergy, education, perception, attitude strength, social acceptance, market acceptance

Highlights

- Bioenergy has little social acceptance
- We studied the influence of information on intentions
- We studied intention to use and the intention to learn about bioenergy
- We found that the lecture was weakly able to improve the intention to use bioenergy
- The degree of improvement was limited by attitude strength

1. Introduction

The successful implementation of bioenergy projects depends on many factors, which can be classified as technical or nontechnical. Rösch and Kaltschmitt (1999) have argued that nontechnical barriers, including financial, administrative, organizational, infrastructural, and perceptual barriers, can have significant negative impacts on the overall costs of such projects. Furthermore, Rösch and Kaltschmitt (1999) noted that these nontechnical barriers can cause significant time delays, resulting in increased costs and decreased investor profits. This paper focuses on perceptual barriers. The latter are important, for even if production has been successfully implemented, the product still has to be accepted by the public before the product can penetrate the market (Schulte et al., 2004). Increasingly, experts have recognized that a lack of social acceptance can be a powerful barrier to reaching Europe's renewable energy targets (Ek, 2005, Zoellner et al., 2008, Norris, 2012, Kaldellis et al., 2013, Wolsink, 2013, Perlaviciute and Steg, 2014).

Following Wüstenhagen et al. (2007), social acceptance can be conceptualized as having three interdependent dimensions: (a) sociopolitical acceptance, (b) community acceptance, and (c) market acceptance. Sociopolitical acceptance is achieved when there is high-level, stable (financial) support for the implementation of a fostering policy (Wüstenhagen and Bilharz, 2006, Bürer and Wüstenhagen, 2009, Mendonça et al., 2009) Community acceptance is obtained when there is local support for siting a specific production plant (Sinclair and Löfstedt, 2001, Upreti, 2004, Upreti and van der Horst, 2004, Upham and Shackley, 2007, Howell et al., 2014). Market acceptance is attained if people are willing to adopt a certain product. This willingness is often proxied by assessing willingness to pay (Hite et al., 2008, Jensen et al., 2010, Soliño et al., 2012). Notably, a consumer's decision to switch to bioenergy (i.e., market acceptance) can be unrelated to a community's acceptance of a specific production facility, since the adoption of the product does not necessarily imply being faced with the downsides of its production. Still, in an increasingly media-saturated world, people need not experience such disadvantages firsthand to have an opinion about bioenergy. It has long been shown that mass media have the power to set agendas (McCombs and Shaw, 1972).

Traditionally, social acceptability is assessed by public opinion polls, which serve to put things on the political agenda (McGowan and Sauter, 2005). Such polls measure whether the public is in favor of or against (a certain form of) renewable energy. In recent times, public support has become an increasingly important predictor of investments of various kinds (Upham et al., 2007, Badera and Kocoń, 2014). Yet the public's views can contain equal amounts of favorable and unfavorable opinions. In psychological literature, the simultaneous presence of both positive and negative evaluations of an object is called 'ambivalence' (Conner and Sparks, 2002). In research focused on Europe and Belgium, bioenergy has been found to be not only the least accepted of all types of renewable energy but also the type the public is most ambivalent about (Eurobarometer, 2007). At the root of this ambivalence lies the heterogeneous nature of bioenergy products. A range of biomass inputs can be transformed via multiple production pathways into various forms of energy outputs. Because the subject is complex, people seem to be unaware of and unfamiliar with the use of biomass as an energy source (Rametsteiner et al., 2007).

In a Japanese context, Tagashira and Senda (2011) have shown that to help people understand bioenergy and increase public support, communication about bioenergy should contain (a) a definition of biomass, (b) details on production technologies, (c) an explanation of the carbon-neutral concept of biomass, (d) a discussion of the nonuse of energy food crops, (e) an overview of the sustainable availability of resources under certain conditions, and (f) a review of the cause of higher costs. Unfortunately, no examples of messages containing these topics were developed, but if they had been developed, the seven *c*'s of effective business communication – courtesy, clarity, credibility, correctness, completeness and consistency, concreteness, and conciseness – would have been helpful (Sehgal and Khetarpal, 2008). These qualities contrast with the qualities of complexity, ambiguity, and contradictoriness that characterize the information people receive via the media (van den Hoogen, 2007). Nevertheless, the media's discourse has been found to be more influential than any other discourse in shaping public attitudes towards unfamiliar and controversial issues (Yin, 1999, Wright and Reid, 2011). As a result, the social acceptability of bioenergy products is in a tight spot.

Plenty of academic ink has been spilled on stakeholders' perceptions of bioenergy. For a systematic review of peer-reviewed literature in English from 2000 to 2013 on this topic, we refer to Radics et al. (2015), who showed that few papers have addressed the public acceptance of bioenergy products in general. The issue that has been most addressed is the specific acceptance of biofuels. For examples, see Wegener and Kelly (2008), Van de Velde et al. (2009), Delshad et al. (2010), Savvanidou et al. (2010), and Cacciatore et al. (2012). Furthermore, regardless of the study's publication date and location, it has been found that people on average have little knowledge and awareness of bioenergy. Also, in terms of gender, women have been found to have a lower level of knowledge concerning bioenergy, but they have also been found to be more supportive than men. Finally, students under 18 were found to have a poor understanding and a more negative view of bioenergy, largely because of their perceptions of the socioenvironmental aspects of bioenergy.

Such findings call for action, since younger generations are important to achieving a transition to a more sustainable society. However, Gossling et al. (2005) estimated that at least one-third of students cannot be reached through any kind of (green) marketing campaign. Instead, providing environmental education is said to be one of the most effective strategies for increasing the public's perception, knowledge, and awareness of the environment and for influencing its attitude towards environmental issues. Stoney et al. (1995) showed that educating people about the importance of the environment is central to its future protection. Education is a powerful tool for social change and must play a critical role in the development of the renewable energy industry. Of the people who can be educated, children have been found to be more open than adults to new subjects (Karatepe et al., 2012), but studies have shown that children can have an influence on their parents' purchasing and other behavioral decisions (Wilson and Wood, 2004, Fell and Chiu, 2014). Furthermore, children have been found to pass part of the everyday knowledge they get from school to their parents (Zografakis et al., 2008).

The current study investigated Flemish students' intention to use and learn about bioenergy. Specifically, our aim was to understand the relationship between knowledge, perception, attitude strength, and attitude concerning bioenergy. In addition, we sought to verify the potential role of classroom instruction in the form of a standardized PowerPoint lecture in changing students' mindset. To the best of our knowledge, the impact of a lecture on the subject of bioenergy has not yet been studied, nor has the defined model been tested for bioenergy in previous studies. When someone introduced as an expert in the matter provides information within the safe haven of the classroom, distrust of the information source should be less of an issue (Ardoin et al., 2016). Hence, the effectiveness of the information was assumed to depend on the message and its ability to capture the audience's attention.

The paper is structured as follows: In the introduction, we show the difficulty bioenergy is facing in gaining social acceptance. In the method section, after providing a brief overview of the models dealing with the relationship between knowledge, information delivery, attitudes, and behavior, we introduce the Flemish context and outline our approach. In the third section, we present the results of the survey questions related to knowledge, perception, and attitudes. We then provide the results of the partial least squares structural equation model. We end by discussing and drawing conclusions from our work.

2. Method

2.1. Research Setup

One of the most influential attitude-behavior models is the theory of planned behavior (TPB) (Kollmuss and Agyeman, 2002). The model was further developed from the theory of reasoned action, which was first developed by Ajzen and Fishbein (1980). In the latter model, the authors assumed that behavior is voluntary. Since this is not entirely correct, they later added perceived behavioral control and named the new model the TPB. In this model, a relationship is described between the latent variables: (a) attitude, (b) subjective norms, and (c) perceived behavioral control, all of which influence (d) intention, which in turn has an impact on (e) actual behavior (Ajzen, 1991). Using such a model, a cross-cultural study has shown that attitude, measured using seven-point rating scales on statements such as 'the use of bioenergy can reduce the threat of global climate change', has the strongest effect on the intention to use bioenergy (Halder et al., 2016).

Originally, the TPB assumed that pre-stored beliefs together with the subjective values of the expected outcomes determine one's attitude towards the behavior. When dealing with largely unfamiliar objects, like bioenergy, such beliefs do not exist yet or may not be very strong. Hence, attitudes about these novel objects are created directly based on information that is accessible at that moment (i.e., attitudes are created directly based on the context). van den Hoogen (2007) showed that for biomass perception, the contextual influence is higher when the attitude strength is weak, and vice versa. The notion of attitude strength includes the idea that attitudes and hence acceptance might change with time if the attitude strength allows for such change.

As mentioned in the introduction, the general level of knowledge concerning bioenergy has been found to be low amongst students, and this lack of knowledge is often seen as a cause for students' low acceptance of bioenergy (Radics et al., 2015). Frequently, it is assumed that the more knowledgeable people are on a subject, the more positive their attitude will become and the more the desired behavior will occur (Sudarmadi et al., 2001, Qu et al., 2011, Kapassa et al., 2013). This assumption is based on the information deficit model of public understanding and action (Burgess et al., 1998), but that model has been proven to be partly wrong (Kollmuss and Agyeman, 2002). As Devine-Wright (2007) noted, there is little evidence that more informed individuals are more receptive to renewable energy technologies.

The present research aimed to investigate how knowledge, perception, attitude strength, and intentions concerning bioenergy are related. Factual knowledge about renewable energy was used to check what our respondents really knew about renewable energy. Perceptions concerning bioenergy were defined as the subjective evaluation of bioenergy-related statements. The concept of attitude strength was operationalized after and contained certainty, importance, involvement, and ambivalence. Although researchers such as Petty et al. (1995) have long demonstrated that when two persons have the same evaluation of an object, the one with the strongest attitude is more likely to be guided by it, this fact is all too often neglected. It has been shown that attitude strength influences the impact of such evaluations on consequent intentions and behavior (Priester et al., 2004). Finally, measurements were taken of behavioral intentions (i.e., intention to use [ITU] and intention to learn [ITL]), which are distinct from actual behavior. A schematic overview of the proposed path model is provided in Figure 1. The model was geared towards testing the following hypothesis:

H1: Providing a classroom lecture supported by a PowerPoint presentation increases the factual knowledge of respondents.

This hypothesis assessed whether standard teaching methods actually succeed in increasing the factual knowledge level. In contrast to what the often cited 'pyramid of learning' contests to, direct instruction has been found to be the most effective technique in improving educational achievements (Kim and Axelrod, 2005). In our study, the classic way of teaching was put to the test. However, it should be noted that the survey was taken immediately after the lecture. Hence, we were not able to test for long-lasting retention effects.

H2: The more knowledgeable respondents will have more positive perceptions concerning bioenergy.

Such an assumption dates back to early linear models that connect more knowledge to a more positive attitude, and this connection would in turn translate into more pro-environmental behavior. Whereas the latter link has been shown to be an oversimplification, the former has been confirmed by research. For instance, Ramayah et al. (2012) and Bang et al. (2000) found a positive relationship between knowledge and attitude. However, research on the relationship between knowledge and attitude in relation to the subject of bioenergy has shown that more knowledgeable individuals are more critical than others (Halder et al., 2010).

H3: Respondents with a more positive perception have a higher ITU.
H4: Respondents with a more positive perception have a higher ITL.

Generally, empirical studies using the TPB have found a positive relationship between attitude and intentions (Armitage and Conner, 2001). However, it has been shown that the relationships with ITU and ITL might not be aligned (Halder et al., 2011).

H5: Attitude strength behaves as a mediator between perception and the ITU.
H6: Attitude strength behaves as a mediator between perception and the ITL.

These hypotheses were brought to life to re-examine the role of attitude strength when differentiating ITU from ITL. Although we expected the hypotheses to be confirmed, we wanted to test whether the classroom lecture influenced attitude strength. We intended to check whether traditional knowledge-based education stimulated (perceived) elaboration and therefore served as an antecedent of attitude strength (Barden and Petty, 2008).

<Insert>*Figure 1.* Path Model of Knowledge, Perception, and Attitude

By providing participants with a standardized classroom lecture, the study investigated the influence that giving information to respondents has on ITU and ITL. The lecture was standardized to maintain uniformity across the different groups. For the same reason, no interaction was allowed during the lecture. The lecture consisted of three parts. In the first part, the relation between sustainable development and renewable energy was detailed by means of the *trias energetica,* The latter outlines how energy is used sustainably. Energy demand should be met by energy savings, renewable energy, and only then should fossil fuels be used as efficiently and cleanly as possible. Further, the European and Flemish renewable energy targets were shown, the current share of renewable energy and bioenergy was described, and the advantages and disadvantages of renewable energy were discussed. In the second part, examples of biomass feedstock, processing technologies, end products, and general advantages and disadvantages were discussed. In a third section, the notions bioeconomy and cascading were carefully explained, after which an introduction to the biobased economy was given. (For more in-depth information on these notions, see Keegan et al. (2013).) In this way, the proper use of the available biomass feedstock was fully nuanced. The lecture took approximately 30 minutes, and each session was given by the same person to provide all students with exactly the same information. Such information could also have been provided by a questionnaire, group interactive process, informative website, social media website, site visit, and so on (Baird and Fisher, 2005, Hobman and Ashworth, 2013, Dowd et al., 2014). Nevertheless, in this study, a classroom lecture was the preferred method of information transfer because classroom lecture is the dominant method used in the Flemish educational system.

2.2 Policy Context and Data Collection

Belgium is far from attaining the national renewable energy targets that are legally binding. In Flanders (northern part of Belgium) the share of renewable energy in the gross final energy consumption amounted to 5.6 percent in 2012, whereas the target is 13 percent by 2020 (Jespers et al., 2014). Note that bioenergy is still the largest contributor to the share of renewable energy in Belgium.

The government has taken initiatives to increase the share of renewable energy sources (RES). One of these initiatives is the formulation of a vision for the bioeconomy in Flanders (Flemish Government, 2013). The bioeconomy is seen as one of the sectors that should enable long-term industrial activities in the region and at the same time contribute to the European targets for renewable energy. Within the vision document, five strategic objectives are formulated, one of which is to put Flanders at the top for education, training, research, and innovation in future-oriented bioeconomy clusters. By implementing the policy priorities regarding the bioeconomy, Flanders also contributes to the European strategy for developing a European bioeconomy (European Commission, 2012).

This study was performed in the province of Limburg (eastern part of Belgium). The study was motivated by the observation that university students, regardless of their study subject, have little knowledge of bioenergy. Moreover, as mentioned in the introduction, students under 18 have been shown to have a poor understanding and a more negative view of bioenergy than other demographic groups (Radics et al., 2015). After inspecting the curricula of secondary schools, we concluded that this poor understanding might be due to the lack of space in the curricula for teaching students about renewable energy. Based on personal communication with several secondary school teachers, it seems that often only one 50-minute period can be given to a lecture on energy-related topics. This time constraint means that teachers can only briefly discuss renewable energy. As a consequence, often only solar and wind energy, which are the most familiar RES in Belgium, are covered. These findings are of concern because renewable energy is a societal problem that must get sufficient attention if a transition is to be successful.

Between December 2013 and March 2014, the present study conducted a survey of Hasselt University bachelor’s degree students, who typically fall in the age range of 18 to 21. In addition, 320 students in the fifth and sixth grade, that are usually 16 to 18 years old, of six different secondary schools distributed all over the Limburg province completed the survey. In total, 715 students completed the survey, and 281 of these received a lecture. An overview of the respondents can be found in Table 1. Nearly all respondents indicated that they were not aware of the presence of a biomass power plant in their neighborhood, although the majority lived within a 10-kilometer radius from an installation. For this reason, the impact of local acceptance on market acceptance was considered negligible. In the remainder of this paper, a distinction will be made between pupils and students. *Pupils* refers to respondents from the fifth and sixth grade, whereas *students* refers to respondents from the university.

The survey contained four different parts that aimed to assess (a) knowledge, (b) perception, (c) attitude, and (d) sociodemographics. The questionnaire was to a large extent based on previous work done by Halder et al. (2010), Zyadin et al. (2012), and Goorix and Meijnders (2003) but was changed slightly to fit the situation in Flanders. The questionnaire consisted of closed, mainly seven-point, Likert-type scale questions (ranging from *totally disagree* to *totally agree*) supplemented with the option *I don't know*. After the questions measuring knowledge, a clear definition of biomass and bioenergy was provided. It took approximately 15 minutes for respondents to fill out the questionnaire. Young people who received and did not receive a lecture filled out the same questionnaire. Those who attended the lecture filled out the questionnaire immediately after the lecture. Questions could be asked only after the survey was completed. The teacher made sure that during the lecture, no opinion was given for or against bioenergy or any other form of renewable energy. Furthermore, the lecture was first discussed with different teachers to make sure the level of the lecture matched the level of the students. An overview of the questions used, translated to English, can be found in Appendix B. The data were collected anonymously.

<Insert> *Table 1*. Overview of Respondents

2.3. Method

Study data were analyzed using the statistical software program IBM SPSS, version 22.0, and smartPLS 2.0. Simple descriptive statistics as well as several nonparametric methods were used to describe and determine differences in respondents' knowledge, perception, and attitudes regarding bioenergy. Using structural equation modelling (SEM), the underlying relationships amongst the different latent variables shown in Figure 1 were investigated. SEM can estimate the measurement model and the structural model at the same time and can account for measurement error (Polonsky et al., 2012). The PLS (partial least squares) method was chosen for several reasons: (a) the model contains formative, reflective, and single-item measures which can be analyzed easily by PLS; (b) PLS avoids making a distributional pattern assumption for the observations; (c) a side benefit of the partial nature of the PLS algorithm is that sample-size requirements are smaller than those for covariance-based methods; (d) PLS allows estimating higher-order models; and (e) PLS works better for complex models; in other words, it works best when the focus is on the interrelationships amongst a large set of factors and when there are many manifest variables (Chin and Newsted, 1999, Chin, 2010).

A structural model describes the relationships between the latent variables, whereas the measurement model describes the relationships between the indicators and the latent variables. The indicators measure the latent variables. The latent variables knowledge, perception, and attitude strength were assumed to be formative, whereas the latent variables ITU and ITL were defined as being reflective. A single-item measurement was used to represent whether a lecture was attended, thus giving rise to the information construct. By convention a single-item measurement model is represented as reflective. It is crucial to correctly define the relationship between the construct and its indicators to avoid biased parameter and standard error estimates for the structural model and to avoid inflated Type II errors (MacKenzie et al., 2005). Jarvis et al. (2003) have provided an overview of the characteristics of reflective and formative constructs. An overview of the full SEM is provided in Figure 2. The indicators are labeled with the question number, as shown in Appendix B. Guidelines dictate that the minimum sample size is obtained by taking the maximum of either (a) the multiplication of the largest amount of arrowheads pointing at a latent variable times 10 or (b) the multiplication of the largest number of formative indicators used to measure a single construct times 10 (Barclay et al., 1995). Moreover, minimum sample-size requirements based on power analysis also indicate that a sample of 715 is sufficiently large. For example, given an *α* of 0.05, we would need at least 174 respondents to achieve a statistical power of 80 percent for detecting R^2 values of at least 0.10. This number decreases as a higher R^2 is detected (Hair et al., 2016).

Perception was measured as a second-order model consisting of three subdimensions, which were defined as the future role of bioenergy (Factor 1), the role of wood as a source of bioenergy (Factor 2), and the sustainability aspects of bioenergy (Factor 3). For estimation, a two-step procedure was used. At the first step, the complete model was estimated with perception defined by all the indicators describing the three factors. The resulting latent variable scores for the three factors were used in a second step as formative indicators for the perception construct. Attitude strength was measured using questions 3.5(1)–3.9 (i.e., questions on certainty, importance, involvement, and ambivalence). The procedure used for perception was used to combine the questions related to ambivalence (3.6–3.9) into one latent variable score. The resulting latent variable score was called 'ambivalence'.

<Insert> *Figure 2.* Structural Equation Model Relating Knowledge, Perception, and Intentions

3. Results and Discussion

3.1. Respondents' Knowledge about Renewable Energy

In the first part of the questionnaire, respondents' general knowledge of renewable energy was tested through a series of closed questions. When processing the results, all respondents were categorized into one of seven knowledge levels, from *very low* to *very high*. The questions in the first part of the questionnaire and the method of categorizing them can be found in Appendix A.

Study results showed that uninstructed pupils and students were most familiar with the RES of wind, sun, and water. Wind and solar energy infrastructure are highly visible in the landscape of Belgium, and this fact might partly explain pupils' and students' high awareness of them. However, the visibility of local infrastructure cannot explain pupils' and students' familiarity with water energy, since water energy is barely available in Flanders. Solar energy was less frequently recognized as a source of renewable energy than wind and water, perhaps because media discussions of solar energy have often dealt with the (unfair) subsidies and thus have given solar energy a pejorative connotation. Biomass and geothermal energy are less known RES. However, more than half the students recognized these sources as being renewable. At the secondary school level, 50 percent of the pupil respondents recognized bioenergy as an RES, and 33 percent recognized geothermal energy as an RES. It is remarkable that 18 percent of the pupils responded that nuclear energy is a source of renewable energy. In addition, 16 percent indicated that oil is renewable, and 8 percent indicated that natural gas and coal are RES, maybe because they did not know what the word *renewable* means. The results differed if a lecture was given. In this situation, most of the students and pupils were able to identify the proper RES. More than 95 percent of these students and pupils correctly recognized bioenergy and wind, water, and solar energy. Fewer students (84 percent) and pupils (76 percent) recognized geothermal energy as an RES.

Mann-Whitney U test results showed that male respondents had a significantly higher knowledge than female respondents when no lecture was provided. This result indicates that Flanders is in line with the general findings presented in the literature. After providing a lecture about renewable energy, no significant gender differences could be found in the level of knowledge. The initial knowledge was higher for students (43 percent) than for pupils (24 percent). However, after the lecture, pupils and students performed equally well in providing the correct answers. This result seems to indicate that a lecture is capable of increasing the factual knowledge level.

3.2. Respondents' Perception of Bioenergy

In the second section of the questionnaire, respondents were presented with several statements that assessed their perceptions of bioenergy. Most of the respondents agreed that an increased use of bioenergy could help to reduce the greenhouse gas effect (73.4 percent) and replace fossil fuels (54.9 percent). Almost all respondents agreed that the government should support bioenergy research and the development of bioenergy. However, the Mann-Whitney U test showed a significant difference between respondents who were given a lecture and those who were not. Respondents who were not given a lecture were more negative about bioenergy's ability to reduce the greenhouse gas effect, and they were more negative about the government's role in supporting bioenergy research and the development of bioenergy. One explanation for this finding may be that many respondents who were not given a lecture were unaware that biomass is an RES. Because of this finding, we expected to find a positive relationship between knowledge and perception in the SEM.

The majority of the respondents did not perceive wood as being environmentally friendly and did not perceive it as being one of Belgium's main sources of bioenergy in the future. The respondents nevertheless indicated that the use of wood for energy production might be justified if the same amount of wood were replanted. The majority of the respondents perceived the use of waste streams as being more environmentally friendly and as being an important source for renewable energy in the future. This is an interesting finding that takes into account the fact that waste streams will gain increasing attention in a bioeconomy in which cascading principles will be of major importance (Van Dael et al., 2013); that is, in a bioeconomy in which biomass sources will first be used at their highest value, as chemicals, human food, or animal feed, and will become energy only when no other usages are feasible.

The results of a Mann-Whitney U test and a Kolmogorov-Smirnov test showed that there was a significant difference in the responses of male and female respondents. Whether they attended a lecture or not, women had more positive attitudes towards bioenergy than their male colleagues did. Again, our findings seem to be in line with the consensus in the literature. Those respondents who were given a lecture perceived the future role of bioenergy to be larger than respondents who were not given a lecture. One explanation for this finding might be that those who were given the lecture became aware that biomass is an RES and learned about the conditions under which more bioenergy is socioenvironmentally desirable. Consequently, we expected that providing a lecture would have a significant indirect effect on perception. Furthermore, pupils had a significantly more positive view of the future of bioenergy than students did. This finding might be explained by the fact that students are more critical if they have a higher level of prior knowledge. Results showed that there was no significant difference based on the educational degree of the mother and father of the respondents.

A Kruskal-Wallis test was performed to check for significant differences based on the level of factual knowledge and the course program of the respondents. The level of factual knowledge seems to have had little influence on perceptions of bioenergy. Taking into account the impact of receiving a lecture (in a two-way ANOVA test), we also found no significant difference in economics' and science students' perceptions of bioenergy. This low influence hints that other factors might be at play.

3.3. Respondents' Attitudes towards Bioenergy

The third section of the questionnaire contained different statements measuring the attitude of the respondents towards bioenergy. The questions fall into two categories: (a) ITU and (b) ITL.

Respondents were relatively positive about the future use of bioenergy as a transport fuel or as an energy source in their house. However, a higher price for bioenergy relative to alternative energy sources decreased their intention to use bioenergy drastically. This result is also in line with the literature. Contrary to the relatively positive ITU, respondents were rather negative about learning more about bioenergy; that is, when respondents were asked whether they would like to learn more about bioenergy, they responded positively but gave a negative answer to questions about whether they would like to discuss the topic with their teachers, friends, or parents and whether they would like to visit a bioenergy plant. In particular, pupils seemed to have a significantly lower ITL than students, regardless of whether they attended the lecture. In addition, respondents who attended a lecture had a lower ITL.

Females were less willing to learn about bioenergy, but much more willing to use bioenergy in the future. Taking into account that females were more positive about bioenergy, it might not come as a surprise that their intention to use bioenergy was higher. A Kruskal-Wallis test indicated significant differences if no lecture was provided based on the degree of the father. Respondents were more willing to discuss the topic at home and were willing to pay more for bioenergy if their father had a higher degree.

3.4. Structural Equation Modelling

The results of the final model are provided in Figure 3. Note that since the negative sign may be confused with the line that connects the latent variables, negative numbers are indicated between brackets. Prior evaluation of the reflective measurement models can be found in Appendix C, and prior evaluation of the formative measurement models can be found in Appendix D. In the remainder of this section, the evaluation of the structural model is discussed, and heterogeneity in preferences is revealed.

<Insert> *Figure 3*. Final Structural Equation Modelling Results

3.4.1. Evaluation of the Structural Model

The structural model in PLS analysis focuses mainly on predictive power in terms of variance explained and the significance of all path estimates.

The model's predictive accuracy is evaluated using the R^2 values of the endogenous constructs (i.e. ITU and ITL). It is difficult to define rules of thumb for acceptable R^2 values because they depend on the model's complexity and the research discipline (Hair Jr et al., 2013). According to Chin (1998), R^2 values of 0.67, 0.33, and 0.19 can be considered strong, moderate, and weak, respectively. Whereas this might be true for disciplines such as customer satisfaction or loyalty, in disciplines such as consumer behavior, a discipline that is more comparable to the discipline of our study, R^2 values of 0.20 are considered high (Hair Jr et al., 2013). Therefore, it can be concluded that the R^2 values in our study are moderate, except for the R^2 value of perception, which is weak. To test for the significance of R^2s, a bootstrap confidence interval for R^2 was calculated by using the equation described in Tenenhaus et al. (2005). The R^2 95-percent bootstrap confidence intervals for ITU and ITL amount to [0.201,0.333] and [0.247,0.379] respectively.

The relationships between the latent variables were analyzed using the path coefficients and a bootstrapping procedure. The results of the estimation are shown in Figure 3; the results of the bootstrapping are shown in Figure 4. The path coefficients all indicate positive relationships except for the relationship between perception and ITL (see Figure 3). Note that path coefficients are standardized and hence can be directly compared. Based on the bootstrapping procedure (see Figure 4), it can be concluded that all relationships were significant, with a significance level of 1 percent, except for item 1.8 under knowledge, Factor 2 under perception, and the relationship between perception and ITL. Consequently, hypotheses H1, H2, H3 are accepted, whereas H4 is not supported. Information has a significant positive effect on knowledge (H1). In addition, knowledge has a significant positive influence on the perception concerning bioenergy (H2). Finally, a significant positive relation was found between perception and ITU (H3). An insignificant relationship was found between perception and ITL, implying that H4 is not supported, since a positive relationship was assumed. A mediation effect exists when a third variable intervenes between two other related constructs. In our study, we tested whether attitude strength mediated the constructs of perception and ITU (H5) and perception and ITL (H6). To test for mediating effects, we followed the bootstrap procedure prescribed by Preacher and Hayes (2008). We first checked whether the direct effects from perception to ITU and from perception to ITL were significant. Both direct effects were significant. Therefore, we included the mediator of attitude strength to check whether attitude strength absorbs some or all of the direct effect. The indirect effects were all significant, with a *t*-value of 5.7 for ITU and 8.4 for ITL, implying that the mediator absorbed at least some of the direct effect. To evaluate how much attitude strength absorbs, the variance accounted for (VAF) was calculated. The VAF was 68 percent for ITU. As a result, it can be concluded that attitude strength has a partial mediation effect in the case of ITU. In the case of ITL, the VAF was not meaningful, since the direct relationship became insignificant. It can be concluded that the mediator fully mediates the relationship. Hence, H5 and H6 can be accepted. An overview of the intermediate results is provided in Table 2.

<Insert> *Table 2*. Analysis of the Mediation Effect of Attitude Strength

<Insert> *Figure 4.* Bootstrap *t*-Values for the Final Structural Equation Model (5000 Resamples)

The impact of omitting an exogenous construct on the R^2 value of all endogenous constructs can also be evaluated. As such, the contribution of each exogenous construct in terms of explanatory power can be compared. The measurement is referred to as the f^2 effect size. Values for f^2 of 0.02, 0.15, and 0.35 indicate a latent exogenous variable's weak, moderate, or substantial influence on the latent endogenous variable (Cohen, 2013). The exclusion of attitude strength would result in a significant drop in the variance explained for ITL, since the f^2 amounts to 0.406. The effect of attitude strength on ITU was weak (f^2 = 0.119). Knowledge has a weak effect on the R^2 value of all endogenous variables. Perception also has a weak effect on ITU and ITL, with f^2 values of 0.105 and -0.028 respectively. Finally, a blindfolding procedure was run to determine the predictive relevance of the path model. From this procedure, the Stone-Geisser's Q^2 value is obtained (Geisser, 1974). For the latent variable ITU, the Q^2 value amounts to 0.173, which means that the model has a medium predictive relevance for ITU. In addition, for the latent variable ITL, the Q^2 value was medium and amounted to 0.207.

3.4.2. Evaluation of Heterogeneity with Respect to Gender

It is important to know whether the relationships in the path model differ significantly based on gender. Becker et al. (2012) warned that the failure to consider heterogeneity can threaten the validity of PLS-SEM results, since incorrect conclusions can be drawn. A multigroup analysis (MGA) is used to check for differences between parameters. We used the nonparametric approach prescribed by Henseler (2012) to perform this analysis. The results of the analysis are shown in Table 3. When the PLS-MGA *p*-value was smaller than 0.05 or higher than 0.95, a significant difference between the path coefficients was found between groups.

<Insert> *Table 3.* Examination of Gender Differences Using Multigroup Analysis

We found significant differences in the relationship between perception and both ITL and ITU. The positive relationship between perception and ITU was larger for female respondents than for male respondents. The relationship between perception and ITL was significant and negative for men but not significant for women. Since males' perception was found to be more negative, it can be concluded that they are more likely to intend to learn more. Furthermore, it can be concluded that the relationship between attitude strength and ITU is significantly stronger for male respondents. No significant differences were found for the relationship between attitude strength and ITL.

3.5. Discussion

First, our study shows that providing more information via a standardized classroom lecture intended to fully explain the benefits of using biomass for sustainable bioenergy production is weakly related to raising the intention to use bioenergy. The evidence for this conclusion is a small, positive, indirect effect of providing information. Consequently, based on a single intervention, we find support for the role of standard classroom teaching methods, which generally aim primarily at cognitive learning (Shephard, 2008), in developing acceptance of bioenergy products. This is promising news for bioenergy producers, since more information is not by definition equivalent to an increased knowledge level and as a result increased acceptance (Perlaviciute and Steg, 2014, Simcock et al., 2014). In addition, the lecture was found to weakly contribute to a better perception and to attitude strength. Barden and Petty (2008) have noted that it is not unusual for a two-sided message (i.e., a message that is open about the pros and cons) to result in greater attitude strength when paired with greater actual thought. If so, the information we provided should increase persistence and resistance to change. Still, it should be stressed that the lecture approach is likely to be insufficient to encourage meaningful levels of behavioral change. It has been shown that influencing actual behavior using only information might be too demanding (Owens and Driffill, 2008, Klöckner, 2015). However, communication is indispensable as part of a wider strategy. Ideally, learners should not only be involved cognitively by a message that is relevant to them, but also actively and emotionally engaged during the process. The sender should be a trustworthy expert, and the advocated behavior change needs to be incentivized and socioculturally accepted for the message to have a better chance of being effective. For instance, if prices of bioenergy are higher, mixed signals are being sent, and these mixed signals discourage behavioral change. Finally, although siting and product acceptance are interrelated, the decision to buy a product can be made independently of siting decisions that have not drawn attention.

Second, although we found that factual knowledge was positively correlated with perception, young people's perception of bioenergy is only weakly explained by factual knowledge of RES and bioenergy, as evidenced by the low R^2. It has been shown that in addition to cognition, affect and inferences from prior actions influence evaluations of an object (Ladenburg, 2009, Truelove, 2012). Because lessons from personal experience are less likely to have shaped young people's perception, we disregarded this option. However, it could be that young people attach great validity (Zajonc, 1980) and great confidence (Edwards and von Hippel, 1995) to affective beliefs, since electricity consumption is more of a hedonic than an instrumental type of behavior. Truelove (2012) has found support for such a claim for several energy sources other than biomass. Moreover, it has been argued that what students learn can be separated from what students (learn to) value (Shephard, 2008); for example, it is possible that students might study to pass an exam without modifying their attitude because of what they learned, a fact that would be indicated by the way they respond or behave afterwards. This outcome is troubling, since it means that increasing people's knowledge does not lead them to a state of cognitive-affective dissonance that would drive behavioral change; they would avoid such a state by separating cognition and affect. To avoid this outcome, any communication-based intervention that aims to increase the sustainable use of biomass for bioenergy production should strive to attain not just cognitive learning goals but affective learning goals as well. Otherwise, students will not internalize the values that require them to behave more sustainably, and consequently, results could be short-lived. Although we found that knowledge contributed to attitude strength, this relation could be the result of the perception of thought induced by the lecture. To the best of our knowledge, perception of thought has not been shown to lead to the same attitude strength as actual thought. In this regard, respondents' rather low intention to learn more about bioenergy might be worrisome, since the willingness to learn and to discuss with peers constitutes the foundation of the affective learning goals' hierarchy (Bloom et al., 1971). However, possibly the items chosen to measure ITL were unappealing to our study group, and discussions with teachers, parents, or friends about bioenergy might have been somewhat unpopular amongst young people when the survey was conducted. Results might have been different if the young people had been asked about their intentions of watching TV documentaries or YouTube videos or of doing an information search by Googling the subject of bioenergy. Furthermore, ITL might rise by using alternative, more interactive (i.e., student-centered) teaching methods, or by offering direct experiences such as site visits. In addition, the transferred knowledge might be more long-lasting depending on the teaching method (Çelikler, 2013). Furthermore, although respondents had a rather negative ITL about the topic, we still advise schools to restructure their current curricula and pay more attention to renewable energy. By restructuring the current curricula and giving more attention to potential solutions, which are currently not covered, schools might help to rejuvenate the interest of young people concerning sustainability. We have noticed a fatigue amongst students surrounding the concept. Consequently, more attention should be paid to avoiding repetition and omission in renewable energy educational program development, as Kandpal and Broman (2014) have suggested. Follow-up studies are needed to test (a) the robustness of our findings when incorporating the effect of prior beliefs and emotions and (b) the long-term effects of (repeated) classroom lectures (using different teaching methods) in changing intentions and behavior.

Third, attitude strength behaves as a mediator for the relation between perception and ITU and the relation between perception and ITL. For the former, we found complementary mediation, meaning that the direct and indirect effect are both significant and point in the same direction. Hence, a small part of the total effect can be attributed to the mediator. However, the multigroup analysis showed that males have a stronger indirect effect and weaker direct effect and are therefore more influenced by the strength of their attitude concerning ITU. (Note that equal proportions of males and females attended the lecture.) For the overall sample of men and women, we found an indirect-only mediation for ITL. This means that the indirect effect is significant, but the direct effect is not. The mediator absorbs all the significance of the direct effect between perception and intention. However, the multigroup analysis indicated that males displayed a significant negative relationship between perception and which is suppressed by attitude strength. This could be due to the fact that males who did not receive a lecture have more knowledge, caused by a higher need for cognition, and therefore attitude strength, but the higher knowledge did not translate into a better perception of bioenergy. Still, their need for cognition might have fed their intention to learn.

4. Conclusions and Policy Implications

Bioenergy is one of the main sources of renewable energy. Hence, it is important to be able to attain the legally binding 20-20-20 targets. However, regulation should proceed in partnership with public support of technical developments. Unfortunately, public support is often driven by perceptions, and public support for bioenergy use has been shown to be lacking and is especially low amongst students regardless of location. In view of the crucial role younger generations will play in realizing an energy transition, this study focused on young people's acceptance of bioenergy. The goal was to identify whether providing grade-school pupils and university students with information influenced relationships amongst knowledge, perception, attitude strength, and behavioral intentions. In this way, we verified whether renewable energy education is indeed the powerful tool policy makers often believe it to be.

The following points relevant for policy makers can be inferred from the present study. First, the general level of knowledge amongst young people from Limburg – and presumably the country – about bioenergy is rather low. The study identified a knowledge gap. Most likely, this gap can be attributed to the failure to see biomass as a renewable energy source. Second, the knowledge level can be improved, at least in the short run, by means of a classroom lecture intended to fully explain the ways in which biomass can be used for sustainable bioenergy production. Whether the knowledge level can be improved over the long term depends on whether the lecture induced actual thought. Third, the lecture, which provided both the pros and the cons of bioenergy, weakly contributed to creating a more positive evaluation of bioenergy. However, respondents differentiated their perceptions based on the type of biomass. Young people were more positive about waste streams than about wood as an input source for bioenergy. In addition, what young people actually know explains perception only to a small extent. Consequently, other factors, like affective beliefs, are likely to be in play, and their role should not be minimized when establishing public support. Fourth, respondents were positive about the use of bioenergy but were less likely to be willing to learn more about it. Consequently, we make a plea for rejuvenating current curricula about bioenergy by pursuing affective learning goals alongside cognitive ones and by attending to potential solutions rather than reiterating problems. Defining end terms is often, as is the case in

Flanders (Belgium), a governmental responsibility. Fifth, the lecture increased attitude strength, which mediates the relationships between perception and ITU and perception and ITL, and thus contributed to a more stable, positive attitude. In sum, our study shows that renewable energy education can increase public acceptance of bioenergy products. However, the effectiveness of that education in driving change is influenced by attitude strength.

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Appendices

Appendix A

Insert Table A.1. Knowledge questions and scoring

Appendix B

Insert Table B.1. Overview of question numbers and related questions

Appendix C

An overview of the results of the overall reflective measurement model is provided in Table C.2.

Unidimensionality: For reflective variables it is tested whether unidimensionality is met. Sahmer et al. (2006) propose to use the latent root criterion which states that the first eigenvalue of the correlation matrix of items has to exceed one, and the second value has to be smaller than one. We use the two stage procedure described by Sahmer et al. (2006). The first stage consists of testing H_0: $\lambda_1 = 1$ and H_a: $\lambda_1 > 1$. According to Karlis et al. (2003), H_a can be accepted if $\lambda_i > 1 + 2\sqrt{\frac{p-1}{n-1}}$ where p equals the number of manifest items and n indicates sample size. For the ITU and ITL constructs, the first eigenvalue should exceed 1.129 and 1.149 respectively. Since the eigenvalues for ITU and ITL are equal to 2.733 and 3.407, we accept H_a. The second stage in the assessment of unidimensionality centers around testing H_0: $\lambda_2 \geq 1$ and H_a: $\lambda_2 < 1$, for which the original Kaiser-Gutman criterium is applied. The second eigenvalue is smaller than 1 for both constructs. Therefore, it is concluded that both constructs can be considered unidimensional.

Indicator reliability: The indicator reliability specifies the part of an indicator's variance that can be explained by the underlying latent variable. At least 50 percent of an indicator's variance should be explained by the latent variable for reflective indicators (*i.e.* loading above 0.70). This also implies that the shared variance between a construct and its indicator is larger than the measurement error (Hair Jr et al., 2013). For both the ITU and ITL construct all the loadings exceed the recommended 0.70 cut-off value.

Construct reliability: For the internal consistency reliability the composite reliability is used as the Cronbach's alpha is sensitive to the number of items in the scale and is more conservative. The composite reliability is acceptable for exploratory research when values of 0.60 or higher are obtained (Hair Jr et al., 2013). For both latent variables ITU and ITL the composite reliability values are above 0.85 which is satisfactory (Nunnally and Bernstein, 1994).

Convergent validity: For the convergent validity (*i.e.* the extent to which a measure correlates positively with alternative measures of the same construct (Hair Jr et al., 2013)) the outer loadings and average variance extracted (AVE) are used. The AVE is calculated as the sum of the squared loadings divided by the number of indicators. The outer loadings are all higher than 0.70 and the

AVE above 0.5 and, therefore, acceptable. An AVE value of less than 0.50 is considered insufficient, as more variance is due to error variance than to indicator variance.

Discriminant validity: The discriminant validity is the extent to which a construct is distinct from other constructs, or in other words is unique. The cross loadings do not exceed the indicators' outer loadings indicating that also discriminant validity is met. Furthermore, the Fornell-Larcker criterion is also met (Fornell and Larcker, 1981). The criterion compares the square root of the AVE values with the latent variable correlations. An overview of the results of the Fornell-Larcker criterion is provided in Table C.1. The table contains the latent variable correlations and the diagonal contains the square root of the AVE.

Insert Table C.1. Test of discriminant validity using the Fornell-Larcker criterion

Insert Table C.2. Estimation results and psychometric properties of reflective measurement models

Appendix D

When compared to reflective models, formative constructs demand a different evaluation of the measurement model as indicators are not correlated. As a result, the criteria used for reflective constructs cannot be directly transferred to formative constructs (Diamantopoulos, 1999).

Indicator reliability: Indicator reliability is examined by verifying whether high correlations exists between indicators. These high correlations are not expected in case of formative measurement models. In this model, *c*ollinearity does not reach critical levels. After checking the variance inflation factor (VIF) values we conclude that multicollinearity does not pose any problems. As a rule of thumb, it is suggested that the VIF should not exceed a value of 10 (Götz et al., 2010).

Using a bootstrapping procedure with 5000 resamples, it is evaluated which indicators are significant and relevant. The results of the bootstrapping procedure for the formative measurement models are provided in Table D.1. The null hypothesis, stating that an outer weight equals zero (*i.e.* has no significant effect), is rejected when the interval does not include zero. From the table it can be concluded that three indicators are not significant and for that reason these are further investigated. Two of the indicators (i.e., indicator 1.8 and Factor 2) are kept within the model. Indicator 1.9 is deleted from the model because its outer loading is not significant.

Construct reliability: It is suggested to use a general question, which might be considered reflective, related to each of the formative constructs in order to evaluate formative measurement model's external validity (Reinartz et al., 2004). However, no question is taken into account in our survey as the questionnaire is already perceived as being too long. As a consequence, the external validity of the formative constructs cannot be evaluated.

Convergent and discriminant validity: Formative indicators do not have to be strongly interrelated implying that the examination of convergent and discriminant validity, using criteria similar to those associated with reflective measurement models, are not meaningful in this context. Still, discriminant validity can be evaluated by testing whether the correlation between constructs are not perfect (*i.e.* equal to one). In this study it is concluded that discriminant validity applies for all formative constructs.

Insert Table D.1. Estimation results and bootstrap confidence intervals for formative concepts