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# Student Knowledge and Attitudes Towards Wood and the Use of Wood as a Raw Material

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**Abstract** – There is much uncertainty about the attitude toward raw wood material use: Is the wide-range use of unprocessed wood recommended or not? In our statistically representative questionnaire survey completed in Győr-Moson-County schools in Hungary, we aimed to discover which components of attitude determine the willingness of future energy users to use wood. A novelty of our study is that we investigated three components of attitude in the context of wood use, i.e., the cognitive, the affective, and the conative components. We used Decision Trees in statistics, hitherto unemployed in wood-related environmental education research, to predict the willingness to use the raw wood material. Our study is relevant to sustainable development and climate protection. Our results revealed that only one-third of participants provided an affirmative response to the question of whether they would use raw wood material. Furthermore, we found that the affective component of attitude is a stronger predictor than the cognitive component, with the conative component not being a predictor. In light of these results, we recommend popularizing forest programs since the attitude-changing effect of forest programs has been confirmed.

**forest programs / experiential pedagogy / tree-related attitude / Decison Tree Analysis / future use of wood / Győr-Moson-Sopron County (Hungary)**

**Kivonat – A tanulók tudása és attitűdje a fához és a fa alapanyagként való felhasználásához.** Nagy a bizonytalanság a faalapanyag használathoz való hozzáállás tekintetében: a széles körű faalapanyag használata ajánlott vagy sem? Statisztikailag reprezentatív kérdőíves felmérést végeztünk Magyarország egy megyéjének iskoláiban és arra voltunk kíváncsiak, hogy az attitűd mely összetevői határozzák meg a fahasználati hajlandóságot, a jövő energiahasználói körében. Vizsgálatunk újdonsága, hogy az attitűd három összetevőjét elemeztük a fahasználat kontextusában, azaz a kognitív, az affektív és a konatív komponenst. A fával kapcsolatos környezeti nevelés-kutatásban eddig a Döntési fák statisztikai modelljét nem használták a fa alapanyag felhasználási hajlandóság előrejelzésére. Így tanulmányunk a fenntartható fejlődés és klímavédelem szempontjából releváns. Eredményeink azt mutatták, hogy a résztvevők mindössze 1/3-a válaszolt igenlően, arra a kérdésre, hogy fa alapanyagot használna. Továbbá azt az eredményt kaptuk, hogy az attitűd affektív komponense erősebben jósol, mint a kognitív, és a konatív komponens nem prediktor. Ezen eredmények tükrében javaslatokat teszünk az erdészeti programok népszerüsítésére, mivel azok szemléletmódosító hatása bebizonyosodott.

**erdei programok / élménypedagógia / fához kapcsolódó attitűd / döntési fa / jövőbeli fahasználat / Győr-Moson-Sopron Megye (Magyarország)**

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## 1 INTRODUCTION

The present study investigates the following research question: What attitudes do children show towards the use of raw wood material? To obtain quantitative data on the issue, we conducted a statistically representative questionnaire survey in Győr-Moson-Sopron County in Hungary. The present study explored the uncertainty concerning the use of wood in every society. For example, Stout et al. (2020) demonstrate that the current generation does not possess solid knowledge of the wood products industry. Moreover, they also identify deficiencies in the knowledge of basic concepts. In the same vein, Polzin – Bowyer (1999) also observed great uncertainty concerning university students' knowledge of forests and wood products. They found that student knowledge of forests and wood products is incomplete and based on significant and all-encompassing misunderstandings.

Outdoor environmental education is one method to fill these knowledge gaps. Prokop et al. (2007) found a significant and positive increase in the attitudes of Slovak students toward biology three days after a field trip. Qu et al. (2011) tested Chinese university student knowledge and attitudes about forest bio-energy in China. They found that students had a positive attitude towards renewable energy in general but a slightly less positive attitude towards forest bio-energy, further highlighting the uncertainty in attitudes about forests and the theme of wood in the context of renewable energies. Qu et al. (2011) concluded that knowledge dissemination via different sources (e.g., teaching, Internet or other media channels) is a significant aspect of energy issues. We wanted to investigate this line of research by examining two more aspects of attitude towards trees and the use of wood in addition to the cognitive aspect: the affective and the conative aspects (see later).

Foreign research results demonstrate that using wood as a raw material positively affects psychological, physical, and mental health: trees in the physical space activate neurological, psychological and physiological responses (Jarmusch 2003, Rice 2004). Furthermore, the use of wood as a building material in schools has a positive effect on student performance and stress tolerance (Elias 1989, Kelz et al. 2011). We focused on extracurricular forest programs organized by schools to obtain data on whether these programs exert a demonstrable effect on the younger generation concerning the use of wood. Our main research aim was to assess existing student knowledge about wood, its use, and attitudes related to wood to determine the factors explaining and predicting the wood use among our participants. The second research aim was to obtain information to assess the conscious willingness to use raw wood material as adults. The third aim was to acquire data on whether out-of-school wood-related activities – such as forest programs, field trips, forest-study tours, tree planting programs, or "campfire" programs in forest clearings – influence attitudes towards wood and the use of raw wood materials.

In line with Prokop et al. (2007), we hypothesized that students participating in such school-related extracurricular activities or wood-related programs exhibit higher scores on the cognitive, affective, and conative components of environmental attitudes towards wood than those who did not participate in such activities. However, due to the explanatory nature of our study, we postulated no hypotheses regarding the importance/weight of the three aspects of attitude.

## 2 FOREST PROGRAMS

Forest programs are of key importance to our research because forests play an undeniable role in public welfare (Országgyűlés Hivatala 2016). Several studies have been conducted on forest school programs, educational paths (educational trails, nature trails) and their positive

effects and changes in environmental attitudes, demonstrating the positive effects these programs have on attitude (e.g., Lampert 2008; Lehoczky 1999, Leskó 2017; Kövecsesné Gősy 2009). Unfortunately, forest school programs are unavailable to many schools and funding opportunities are also limited (Leskó 2017). Taking these facts as a starting point, we explore the effects of shorter-term programs that require no funding. Students participating in public education participate in forest programs several times a year as part of the school curriculum. Therefore, forests can become a new educational site, a novel educational institution (Lohri – Schwyter 2002). Well-organized excursions, forest visits, walks, and forest school activities provide a lasting experience for children, with experience being an emotional phenomenon that affects the child due to its strong emotional charge. Thus, such interventions are meaningful educational tools (Hartl 2008). Moreover, forest programs aid the development of critical and independent thinking by promoting the development of environmentally conscious behavior and environmental responsibility via the formation of attitudes, values, emotions, and knowledge expansion about the environment, society, and culture. For example, by exploring the surrounding mountains and educational trails, students can develop orientation and map-using skills, physical and motor skills, and coordination.

During these programs, a forester can aid teachers through their knowledge of environmental problems. Foresters can also expand environmental knowledge in students (Lohri – Schwyter 2002, Kováts-Németh 2011). To the best of our knowledge, no research has been conducted on the use of wood in connection to whether extracurricular forest programs organized by schools (walks, excursions, "campfire" programs in the forest) have an impact on current primary and secondary school students. We focused exclusively on wood use because the topic has become highly relevant throughout the world due to the energy crisis. This distinguishes it from other themes related to school forest programs such as handcrafts, preserving cultural-historical traditions, field study, or health preservation. A second motivation is the uncertainty surrounding using wood as an energy source and wood use in general.

We chose the primary and secondary student age groups because these students will eventually become future energy users. The topic of the present paper is important from several aspects. On the one hand, from the forest management perspective, our research provides information on the willingness of the next generation to use raw wood material. From the point of view of climate protection, the carbon sequestration role of raw wood materials is significant, which is also relevant to future renewable energy sources. Our research is also meaningful for environmental education (including adult environmental education) and exploring new ways and opportunities to promote sustainable development through education. In the following, we elaborate on these aspects and present our statistically representative study. Subsequently, we discuss the results, draw conclusions, and provide suggestions for out-of-school forest program opportunities with a specific focus wood use.

The present topic is relevant to forest management due to the misinformation the media and nature conservationists tend to convey about wood (e.g. Kováts-Németh 2010). Citizens also misjudge wood material use and tend to view the work of foresters negatively (Gregory 1996, Kováts-Németh 2010, Folcz 2013, Lomniczi 2018). For example, wood as an industrial raw material is a missing natural resource in public thought (Hartl 2008). Therefore, one of the uncertainties in recent decades is the growing concern about global deforestation and forest degradation (Paquette – Messier 2010, Donato et al. 2011, McNeill 2011). The deteriorating state of forests, the accelerating growth of the global population, and the increasing penetration of nature also affect the use of raw wood material (e.g., Kováts-Németh 2010). Concerns about wood extracts and wood substitute use are increasing, resulting in a trade-off between wood products and wood substitutes. Industries replacing

wood products with other materials also believe their products have environmental benefits, adding to the mentioned uncertainty (Durugy 1996, Kováts-Németh 2010).

Scientific evidence suggests that wood product use in construction and everyday life positively affects the climate (Az Európai Unió Hivatalos Lapja 2015). Wood use in furniture and building materials, together with its storage capacity, leads to decades- or centuries-long atmospheric carbon sequestration (Antal 2014, Carle et al. 2002, IPCC 2000, National Forest Strategy 2016-2030, Rumpf 2011, The Elias Review 2008).

According to the Hungarian National Forest Strategy for 2016-2030 (National Forest Strategy 2016-2030), the expanding and multi-stage sustainable use of harvested timber in the timber industry will help reduce climate change effects. Moreover, wood products should be used for energy recovery at the end of their life cycle following circular economy principles. Brechin (2003) reviews concerns about global warming on several continents and examines the effects of burning fossil fuels. The countries he studied are uncertain about global climate change (Brechin 2003). The natural sciences have demonstrated a clear link between empirical evidence on atmospheric gas composition and terrestrial climate change (e.g., CIFOR 2013; WRI 2008). The short-term enrichment of greenhouse gases such as carbon dioxide, methane, and nitrous oxide will lead to changes in the heat balance of the atmosphere, which in turn will be reflected in climate change. The amount of carbon stored in forests in the form of wood cannot be neglected, as forests are the most efficient carbon dioxide ($CO_2$) reservoirs in the Earth's atmosphere after plankton stocks in oceans. Therefore, increasing and preserving forest areas contributes much to maintaining global carbon turnover.

The Official Journal of the European Union contains the European Economic and Social Committee's (EESC) opinion on the contribution of the forest-based sector to carbon balance. The opinion concludes and makes recommendations for increasing the wood supply and the sustainable use of wood as a raw material. The EESC urges Member States to develop national action plans to increase wood in buildings and green infrastructure. In sum, the EESC promotes a culture of wood use in buildings, thereby reducing $CO_2$ emissions.

The role of forests and trees in the next century may be greater than ever before, with forests being the most complex natural (ecological) system on Earth and one of the basic supporters of human life. Forests play a key role in the protection of soil, the atmosphere, and the climate. As a renewable natural resource, forests produce raw materials, energy, and food in addition to the continuous improvement of the environment (Act XXXVII of 2009 on the protection of forests).

## 3 ENVIRONMENTAL EDUCATION AND ENVIRONMENTAL ATTITUDES

The international professional community believes education should create values for a sustainable future and promote behavior and lifestyles (Cseri ed. 2003, p. 14; Larson et al. 2011, Leeming et al. 1995). The National Core Curriculum in Hungary has been revised several times and now includes environmental education, sustainability and environmental awareness as priority areas for development (National Core Curriculum 2021). In line with the National Core Curriculum, Hungarian researchers have examined the importance of environmental education. They have concluded that environmental education can help children develop habits and behaviors that form the basis of a balanced relationship with their environment in their adult lives (Ádam 2007). As a result, environmental education and sustainability have also gained a new approach and content in Hungary. According to Havas (2001), environmental education includes values that serve as sustainability prerequisites, making the relationship between the two concepts indisputable. In this vein, Ádam and Boldis

also underscore that the balance between man and nature should be the goal of environmental education (Ádam – Boldis without years).

The link between sustainability and environmental education raises the question of how environmental education can be improved in the context of wood and trees. Studies to determine the positive influencing of environmental attitudes are also underway. For example, Halász et al. (1979) and Paksi (2013) suggest many ways to achieve states of mental and neural calmness through experience that has a dynamic or controlling effect on an individual's response to all objects and situations to which the attitude applies. Researchers distinguish three domains of environmental attitudes: the cognitive domain (component) referring to knowledge in general, the affective domain (component) encompassing emotions and the conative domain (component) referring to actions and behavior in the present or the future (Allport 1935, Maio – Haddock 2010). Among the factors influencing the development of effective environmental attitudes, the direct environment, learning environments, the impact of human interventions, and the physical environment of schools have been studied in a domestic and international research context (Izadpanahi et al. 2015). However, a sophisticated analysis of these three attitude domains in has not been completed the context of wood and trees. The present paper provides such an analysis and investigates these three attitudes separately to determine whether they explain and predict the willingness of future wood use.

In addition to institutional education, the significant role that family plays in the environmental education context is worth noting. Molnár (2009) shows that promoting an environmentally conscious lifestyle and developing environmental attitudes are crucial mediums for environmental education in families with children. Besides family, the living environment also plays a habit-forming role in environmental education. Konyha (2011) examined the environmental attitudes of high school students, their attitudes toward environmental issues, and differences in environmental attitudes across places of residence. Konyha (2011) showed that students living closer to nature in the countryside have more positive environmental attitudes than those living in cities. This finding is also in line with Conell et al. (1999), who studied the environmental attitudes of students from 15 countries in different places of residence. Konyha (2011), who also analyzed the three domains of environmental attitudes, and found the emotional aspect to be stronger than the behavioral aspect. This finding is significant to our research question. Further, Konyha (2011) found that younger students displayed more positive environmental attitudes. Moreover, children with a positive attitude tended to come from families emphasizing environmental protection (Konyha 2011). To support the thesis that family is a vital factor in environmental education, Rickinson (2001) reviewed more than 100 empirical studies, scholarly articles, and books that presented findings and gaps in the effectiveness of environmental education. The age groups studied were primary and secondary school students. Several studies reviewed by Rickinson acknowledge the family's role as a source of environmental information: after television and school, it is the next most important source of information for young people. However, research cannot unequivocally confirm whether attitudes determine action or behavior; conversely, whether behavior influences attitudes (Formádi 2013). Taking the attitude theory by Atkinson and colleagues, Formádi (2013) argues that the influence of attitudes on behavior and action is stronger when the cognitive and affective components are strong, consistent, and experiential. Formádi (2013) further suggests that specific attitudes towards a specific object or phenomenon are more effective. In the following, we present our study examining the relationships between forest programs and the willingness to use raw wood material. This study and the statistical analysis are explorative in that we wanted to discover the driving factors for the subjective importance of wood.

## 4 MATERIALS AND METHODS

We conducted a county-wide questionnaire in Hungary to investigate the attitudes of the upcoming generation by surveying the age groups of the 7th year of primary school and the 11th year of secondary school. The survey was conducted in Győr-Moson-Sopron County in Hungary during April, May, and June of the 2021 school year. A decisive factor in the county selection was the high tree cover density in the region, which opens up possibilities for tourist- and educational trails, visitor centers, and forest schools in the surrounding forests. A second reason was that this is the only county in Hungary offering a vocational training program, i.e., professional training in forestry and the wood industry.

We piloted the survey questions on ten students before administering the questionnaire. The ten participants were selected randomly, and they were debriefed after filling in the questionnaire. The questions were adjusted to the level of the age groups under investigation and the questionnaire length. Informed parental consent was collected before completing the survey. The questionnaires were administered online using Google Docs during regular school classes with no time limit for filling in the questionnaire. Neither the teachers nor the participants were aware of the study hypotheses. The raw data supporting the study findings are accessible in the Data Availability section at the end of the manuscript.

Our questionnaire was completed by 230 male and 200 female students. The youngest respondent was 10 years old; the oldest was 20 years old (mean age=14.56 years, SD=2.18 years). The total number of 430 participants, and the relevant sociodemographic variables, were counterbalanced to make the county-wide questionnaire survey statistically representative of the county. These relevant variables –submitted to stratification weighting – were gender, age, school type, and settlement size. Our sample is hence a proportional reflection of the specific characteristics in the target population, i.e., Győr-Moson-Sopron County. Based on the data from the Central Statistical Office in Hungary, abbreviated as KSH in Hungary, in Győr-Moson-Sopron County, there were 33,996 pupils enrolled in primary schools and 7,507 enrolled in secondary schools in 2014 (KSH; Központi Statisztikai Hivatal 2015, p. 12). The sample size calculation changes little for populations larger than 20,000[†] (Daniel 1999); therefore, we used 2014 data. To be statistically representative according to the formula for representativeness calculation – a target population size of around 41,500 students, with a margin error of 5%, and a confidence interval (*CI*) of 95% – the present study required 381 participants (Daniel 1999). Given the target sample size of 41,500 and the actual number of 430 respondents, the margin error decreased to 4.7% [95% *CI*]. This margin error indicates a 95% probability that the target population in this county would pick a value on any item, with the value lying within the interval of +/- 4.7%. Furthermore, this sample size is in line with other studies in the field: Qu et al. (2011) tested 441 students using a questionnaire study on forest bio-energy in China.

The questionnaire contained 49 questions (items) comprising categorical variables and a few ordinal variables (see *Table 4* and *Appendix*). After the sociodemographic variables in the questionnaire, questions followed related to respondent habits in school and family, traditions, feelings, and the willingness to use wood in the future. The questions were not randomized or pseudo-randomized across participants because we expected no order effects usually associated with other types of questionnaire studies. Fatigue could be such an order effect (e.g., respondent attention may have slipped towards the end of the questionnaire) or the tendency of some questions to affect response behavior by appearing later in the questionnaire. In the debriefings, participants reported no inconsistencies in the questionnaire.

[†] For an online sample size calculator of statistical representativeness, see https://www.checkmarket.com/sample-size-calculator/ or https://www.qualtrics.com/de/erlebnismanagement/marktforschung/stichprobenrechner/

When recruiting respondents, we ensured that we achieved a proportion of primary and secondary school students representative of the county (see *Table 1*).

*Table 1. Types of schools surveyed*

| | Frequency | Percentage |
|---|---|---|
| Primary school | 230 | 53.5 |
| Four-year grammar school | 20 | 4.7 |
| Six-year grammar school | 15 | 3.5 |
| Eight-year grammar school | 42 | 9.8 |
| Vocational secondary school | 123 | 28.6 |
| Total | 430 | 100.0 |

We included differently sized settlements in the county for the sample proportionally. We distinguished three settlement types in line with the definitions provided in a Hungarian geography textbook (Földrajz tankönyv 8. lecke: Települések Magyarországon [Geography textbook, lesson 8: Settlements in Hungary], 2022): village, town (town: 10-25 thousand inhabitants), and city (city: over 25,000 inhabitants). Table 2 illustrates the participant locations and where participants grew up to explore how many students grew up in the countryside close to nature until they were 12.

*Table 2. Location of schools participating in the survey and information about where the participants in the survey grew up until the age of 12*

| | *Type of location of students' schools* | | *Type of location of upbringing until the age of 12* | |
|---|---|---|---|---|
| | Frequency | Percentage | Frequency | Percentage |
| Village | 59 | 13.7 | 148 | 34.4 |
| Town (town: 10-25 thousand inhabitants, e.g., Csorna, Kapuvár) | 104 | 24.2 | 86 | 20.0 |
| City (city: over 25 thousand inhabitants, e.g., Sopron, Győr) | 267 | 62.1 | 196 | 45.6 |
| Total | 430 | 100.0 | 430 | 100.0 |

## 5 STATISTICAL ANALYSES

For the statistical analyses, we used the RStudio 1.1.442 (RStudio Team 2020) built on the R platform (R Development Core Team 2021, version 3.5.1). First, two independent raters performed a plausibility check to screen for outliers, such as respondents who completed the questionnaire randomly. The raters identified no such respondents. Following this, we computed summary statistics on the data to describe central tendency (mean, median, minimum, maximum, range, and standard deviation). There were two variable types in our dataset: nominal variables and ordinal variables, the latter measured on a 5-point Likert scale. With ordinal variables, we adopted the Hungarian grading system.

The main goal of the inferential statistical analysis, using a high number of potential explanatory variables, was to explain why participants find wood important (see variable "Importance of Wood"). It should be noted that the outcome variable "Importance of Wood" is an ordinal variable representing a continuum, entailing that a value on this variable can only be interpreted in reference to another value. Another implication of the ordinal nature of the outcome variable is that importance is a continuum. To operationalize the subjective

importance of wood, we accept the values of 4 or 5 (indicating subjective importance on a scale of 1-5).

To address concerns about multicollinearity and non-linearity between dependent and independent variables, which are usually associated with multiple regression analyses, we employed the method of Conditional Inference Trees (Hothorn et al. 2006) to investigate which independent variables can account for the outcome variable "Importance of Wood". In statistics, multicollinearity is a phenomenon in which one independent variable can be linearly predicted from the others. Conditional Inference Trees can be used for a broad variety of variable types, such as nominal or ordinal response variables (Levshina 2015). Another reason to employ Conditional Inference Trees was to examine the whole variable space of eight potential explanatory variables in its entirety rather than separately as in the case of other traditional statistical procedures. The conditional inference model is flexible and, most importantly, generalizable (Hothorn et al. 2006).

For demonstrations of the use of Conditional Inference Trees in, for instance, the domain of linguistics, see e.g., Tagliamonte – Baayen (2012), Levshina (2015), Hentschel et al. (2019), or Fekete (2021). Conditional Inference Trees are essentially non-parametric regression models visualized as decision trees and serve as an alternative to multiple regression analyses in the presence of many potential predictor variables and the case of multicollinearity (Levshina 2015). With eight variables, we assumed potential multicollinearity.

Conditional Inference Trees employ an algorithm of recursive binary partitioning and split the dataset into partitioning variables that show an association with the outcome variable. The splitting process terminates when pre-defined stopping criteria are met. Hothorn et al. (2006) describe the methods of Conditional Inference Trees in detail. Decision trees in statistics are structures comprising so-called nodes and branches, starting at a single root node at the top of the decision tree and ending in terminal nodes (or leaves). At each node (or level), a single independent variable is considered for splitting the data into two partitions. The higher the variable in the decision tree hierarchy, the more important the variable, with the highest-level variable being the most important. Conditional Inference Trees were implemented with the party R package using the *ctree* function (Hothorn et al. 2006).

For the Conditional Inference Tree analysis, we entered the following eight independent variables as potential predictors of the outcome variable "Importance of Wood" (for all the factor variables in the study, see Table A in the Appendix). Table 3 illustrates the questions in the survey with the aspects of attitude.

*Table 3. The questions related to the three components of attitude (cognitive, affective and conative components of attitude)*

| | *Component of attitude* |
|---|---|
| If the participant has ever taken part in a program where some old wood-related profession was shown | cognitive |
| If the participant has ever taken part in a school program or school camp related to wood | |
| If the participant has ever attended a "campfire" program | |
| "sadness-scale": "How sad would you feel if a wood-related tradition got lost?" | affective |
| Later, when the participant is an adult, does (s)he plan to plant a tree? | conative |

We restricted the number of variables to this set of five items because the three components of attitude were operationalized via these variables, and we wanted to test only these aspects of attitude. All these variables are nominal variables except for "How sad would you feel if a wood-related tradition got lost?" and the "Current living environment?". The outcome variable "Importance of Wood" is also ordinal.

In the Conditional Inference Tree analyses, the raw data are submitted to the analyses, i.e., participant-level data, and not the aggregated data such as percentages, averages, medians, etc. We built a three-level tree structure to avoid so-called pathological splits associated with more levels (four or more). A pathological split would be a terminal node with very few participants or responses. Such a pathological split should be avoided for reasons of generalizability, i.e., the model might be over-fitted.

Importantly, we did not perform model-validation (cross-validation) on the data to assess the accuracy of the model because when using "mincriterion=0.95" in the model, no cross-validation is needed: "This statistical approach ensures that the right sized tree is grown and no form of pruning or cross-validation or whatsoever is needed." (Hothorn et al. 2021, p. 9)

## 6 RESULTS

Altogether 430 respondents filled in the questionnaire. *Table A* in the Appendix lists the results of all the factor variables in the dataset. *Table 4* contains the summary analysis of all the ordinal variables in the dataset.

*Table 4. A summary analysis of all the ordinal variables in the dataset*

| The ordinal variables in the questionnaire | n | Mean | SD | Median |
|---|---|---|---|---|
| How sad would you feel if you saw a sick or dead tree? | 430 | 2.98 | 1.20 | 3 |
| How sad would you feel if a wooden tool broke? | 430 | 3.27 | 1.25 | 3 |
| How delighted do you feel if you see an old wooden object? | 416 | 3.26 | 1.29 | 3 |
| How important is it where people lived before? | 430 | 3.38 | 1.17 | 3 |
| How beautiful do find a wooden farmhouse? | 430 | 3.9 | 1.11 | 4 |
| How likely would you participate in a wood-related program? | 314 | 3.25 | 1.43 | 3 |
| Have you ever been to a program where old wood crafts were shown to you? | 330 | 3.35 | 1.36 | 3 |
| How sad would you feel if you missed a program with campfire? | 394 | 3.59 | 1.33 | 4 |
| How sad would you feel if a wood-related tradition was lost? | 430 | 2.78 | 1.37 | 3 |
| How important do you think that we should use much wood nowadays too? | 430 | 3.48 | 1.10 | 3 |

*The number of responses are represented by "n". SD designates standard deviation of the mean. Min and Max refer to the observed Minimum and the observed Maximum value of the ordinal scale. Range is the span of the scale.*

*Table 4* shows that some ordinal variables have missing values reflecting unanswered items by the respondents because these items did not apply to a subset of respondents. For example, those who have never participated in a campfire could not answer the question as to whether they would feel sad about missing such an experience. Because Conditional

Inference Trees can combat missing values (Levshina 2015), missingness does not pose a problem for the subsequent analysis.

Before moving on the analysis via Conditional Inference Trees, we would like to focus on the uncertainty among students regarding the use of wood. The responses of 430 primary and secondary school students who participated in the survey revealed that 37.7% (162 people) are influenced by the fact trees felled for use, i.e., they would not use wood because trees are felled. In contrast, 29.3% of the surveyed students (126 people) answered the question with "I don't know", while 33% (142 people) were unaffected by the use of wood, i.e., they would use wood despite it being cut down. Thus, our survey data support the uncertainty about the use of wood as a base material.

The following eight potential explanatory variables were entered in the conditional inference tree analysis: School_wood_programme (if the participant has ever taken part in a school program related to wood), Tree_planting_adult (if the participant plan to plant a tree as an adult), Wooden_craftsman_shown (if the participant has ever taken part in a program in which a craftsman using wood was shown), School_campfire_activity (if the participant has ever taken part in a "campfire" program organized by the school), Current_living_environment (the current living environment of the participant), Campfire_attended (if the participant has ever attended a "campfire" program), Wooden_tradition_currently (if there is an old wood-related tradition currently in the present location of participant), and Scale_wooden_trad_lost (How sad the participant would feel if a wood-related tradition was lost).

*Figure 1* illustrates the Conditional Tree Analysis results explaining and predicting the ordinal outcome measure "Importance of Wood". Each significant explanatory variable is represented by an oval circle together with the Bonferroni-corrected p-value. Classification rules are represented by levels of the significant explanatory variables expressed in the form of if-then conditions. Classification starts at the top node (see *Figure 1*, node 1), which is the most important variable in predicting "Importance of Wood" ($p<0.001$). Classification proceeds by moving down the branches until the terminal nodes marked in green are reached (see *Figure 1*). The number of responses on the routes is represented by *n*, which adds up to the total number of observations of 430 (*Figure 1*).

Node 1 is "Scale_wooden_trad_lost" (How sad would you feel if a wood-related tradition was lost?) proved to be the most important variable explaining and predicting the importance of wood, portioning the data into two sets (see the two routes in Figure 1): data on the scale of the variable "Scale_wooden_trad_lost" which were either 4 or 5 or lower than 4 (see the left and the right branches, respectively). We operationalize "important" on the variable "Importance of Wood" as a value of at least 4 on a scale of 1-5, whereby 5 means the participant finds wood very important. A cohort of 73 participants from 430 children scored a mean of 4.205 (see Figure 1, the leftmost green rectangle at the bottom). The most important variable ("Scale_wooden_trad_lost") reflects the *affective* component of attitude in line with Konyha (2011), who also found that the emotional aspect of environmental attitudes is stronger than the behavioral one. From a pedagogical point of view, this result demonstrates the need for strengthening the affective aspect of wood in environmental education in family, institutional, and out-of-school settings. Specifically, this result shows that conveying information on tradition-related wood is of utmost importance in environmental education.

If we follow the first route (values of 4 or 5 on the scale), then the next variable that splits the data into two is "School_wood_programme" (If the participant has ever taken part in a school program or school camp related to wood). This variable reflects the *cognitive* component of attitude, demonstrating the need for strengthening the knowledge aspect in environmental education both in family, institutional, or out-of-school settings. This variable further partitions the dataset into two (either "yes" or "no"). The *conative* component of

attitude did not appear in the decision tree model, indicating the superiority of the affective and cognitive components. Crucially, the rest of the routes (the four green rectangles) lead to mean values below 4, indicating mediocre or no interest in wood use. Figure 2 is the same representation as *Figure 1*, with the only difference being the distribution of responses on the outcome variable, which are indicated at the bottom of the figure (see nodes 3, 4, 7, 8, 9).

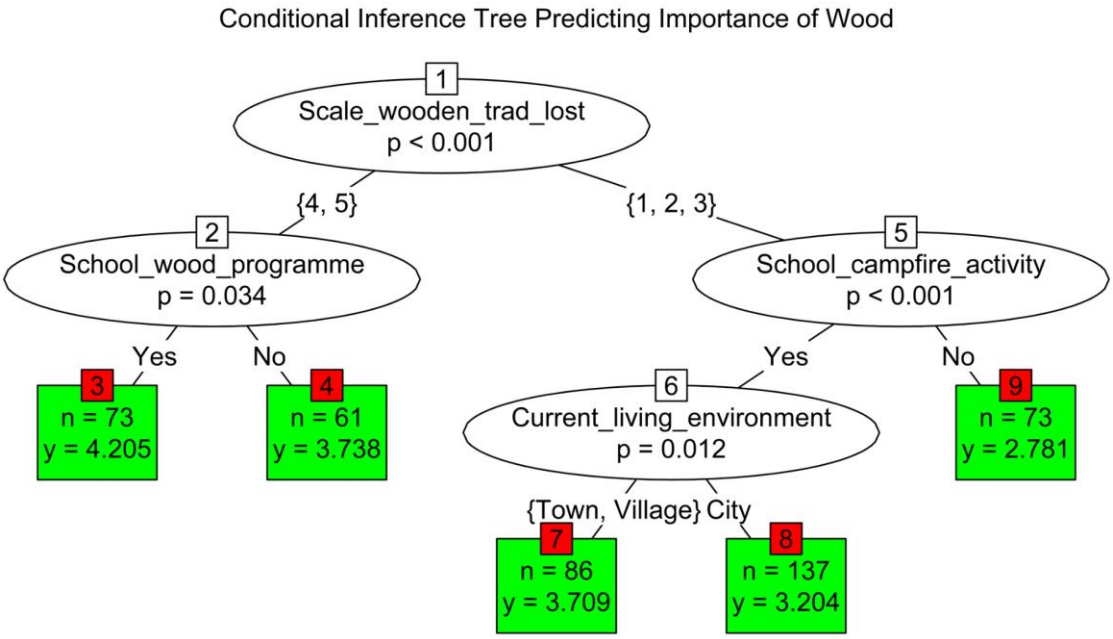


*Figure 1. A Conditional Inference Tree structure explaining and predicting the ordinal type of outcome measure "Importance of Wood". Each significant explanatory variable is represented by an oval circle together with the Bonferroni-corrected p-value of the significance test. Classification rules are represented by levels of the explanatory variables expressed in the form of if-then conditions. Classification starts at the top node (root, node 1), which is the most important variable in predicting "Importance of Wood" (p<0.001). Classification proceeds by moving down the branches until we arrive at the terminal nodes marked in green. The number of responses on the routes is represented by "n".*

*Figure 2* illustrates the distribution of responses along the routes in the model. The leftmost route (Node 3) explains and predicts a high level of "Importance of Wood" in contrast to the rightmost route (Node 3). In both cases (Nodes 3 and 7), outliers can be observed (marked by an empty circle). Variables that do not appear in the decision tree structure are not relevant to explaining the outcome variable "Importance of Wood" in the presence of the variables in the model. In other words, including those variables would not improve classification accuracy significantly. However, this does not mean that the rest of the variables are not significantly associated with the outcome measure "Importance of Wood".

The following bullet points summarize the main insights:

- The *affective* component of attitude at the top of the tree model is of utmost importance in environmental education related to wood (emotions about traditions)

- The *cognitive* component of attitude depicted in the oval circle numbered 2 is second-most important in explaining and predicting the subjective importance of wood (participation in wood-related school programs)
- The *conative* component of the attitude (if they plan to plant a tree later in adulthood) does not appear in the structure of the decision tree.

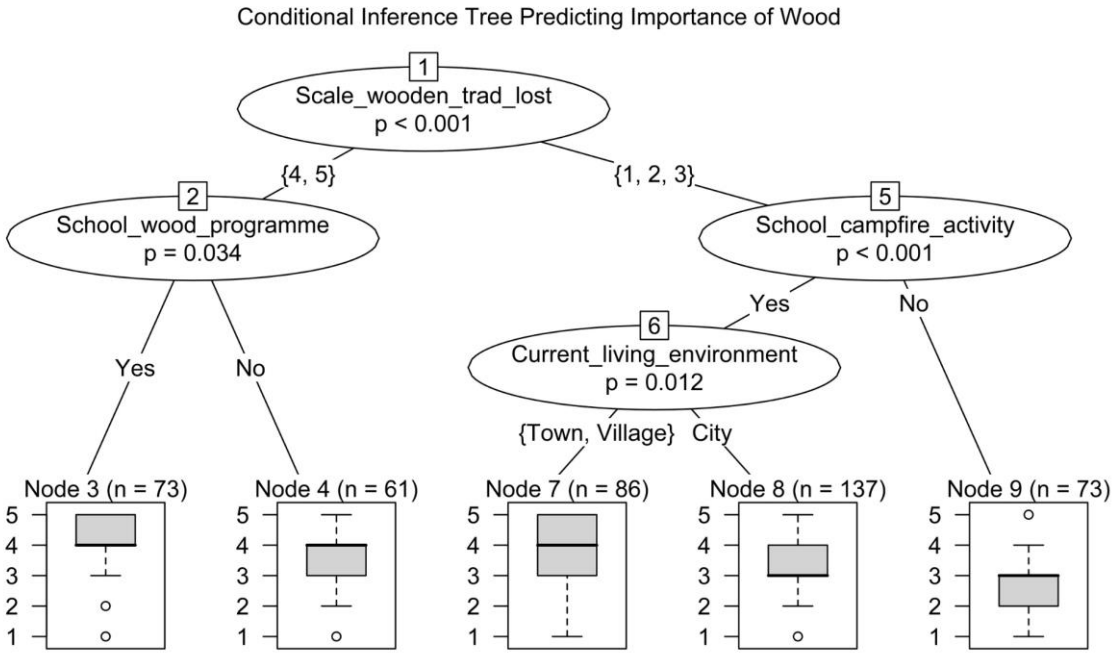


*Figure 2. A Conditional Inference Tree structure explaining and predicting the outcome measure "Importance of Wood" with the distributions of responses at the terminal nodes. Oval circles in the representations at the terminal nodes designate outliers. Figure 2 is another representation of Figure 1: in Figure 2, the distribution of responses per node is illustrated.*

## 7 DISCUSSION AND CONCLUSIONS

Let us begin by looking at the statistical representativeness of our survey. We surveyed just one county in Hungary, which raises a point of criticism about whether the results can be generalized to other counties. Considering the national standards in the curriculum across Hungarian counties, we do not expect any significant differences in the results relative to other Hungarian counties. Therefore, we argue that our survey findings can be generalized to the student population under investigation in Hungary. One potential study limitation is socio-economic status, which was not controlled. However, we argue that the effect of this potential confounder is reduced due to the relatively large sample size.

The "Decision Tree" model (Conditional Inference Tree) results showed that students who would regret the loss of a tree-related tradition and at the same time had participated in forest programs, trips, and events organized by their school, were likely to consciously use wood-based materials as adults. Our results revealed that the cognitive and affective domains of tree-related attitudes need to be strengthened in environmental education and the development of an environmentally conscious lifestyle. The finding that these two attitude components proved to be significant is in accord with Formádi (2013), who argues that the influence of attitudes on behavior and action is stronger when the cognitive and affective

components are strong. The conative component did not prove to be a significant predictor of whether participants find wood important or not. We explain this finding by the nature of the conative component, namely that it refers to future action. The cognitive and affective domains have proven to be predictors in the model, as these two domains reflect the knowledge and emotional attitude acquired in the past and still exist in the present. However, the conative domain presupposes future actions, making this component an unstable predictor of behavior because the age of the interviewed students does not yet allow them to make independent decisions on all issues.

Regarding the hierarchy of the affective and the cognitive components, why the affective component ("emotion") is superior to the cognitive ("ratio") component requires explanation. The affective component is deeply rooted in our experiences, with first-hand experiences being more dominant in guiding behavior than our vicarious knowledge (the cognitive component). Formádi (2013) also underscores that the link between attitude and behavior is stronger when the attitude is based on direct experience. Note that direct experience is the basis of the affective component of attitude. Our findings also concur with Konyha (2011), who found that the emotional aspect is stronger than the behavioral aspect.

Concering the significant predictors in the decision tree, node 3 (Figure 1) proved to be the route that best describes those students for whom wood is important (Figure 1): in our sample, this is a small cohort of 73 students with an average of 4.205 on the importance scale (see node 3, Figure 1). These students have already participated in a school program related to wood (node 2 of Figure 1) and – at the same time – responded with 4 or 5 on the "sadness-scale" (node 1 of Figure 1). In contrast, an equal number of students (n=73) display the opposite pattern: these are students who did not take part in a school-organized campfire program and who – at the same time – gave a response of 1, 2 or 3 on the "sadness scale" (node 9 of Figure 1). This cohort does not find wood important at all, as shown by an average of 2.781 on the "importance scale" (Figure 1). The current living environment of the participants also proved to be a significant predictor of importance, with towns and villages showing a slight advantage relative to cities (node 6 of Figure 1). However, we believe that this result should be validated because the living environment in which the students grew up is more natural than their current environment. Figure 2 shows that the distributions do not vary (see terminal nodes in Figure 2), indicating that the predictive routes in the decision tree are comparable.

Our findings, in turn, illustrate that strengthening the first two components of attitude will promote the development of environmentally conscious behavior. Therefore, we recommend that teachers organize as many extracurricular forest programs as possible, following the recommendation by Qu et al. (2011). Importantly, a qualified specialist should organize such programs. For example, programs can be based on a forester's knowledge and professional knowledge. To strengthen the use of wood, we recommend promoting programs in which families with children can participate, in line with the research of Molnár (2009) and Rickinson (2001), who also confirmed that family is an important medium. To strengthen the use of wood as raw material, we suggest emphasizing affective attitudes, which can only be achieved if students spend as much time as possible in the forest, where they receive experience-based pedagogy. In the context of Konyha (2011), the difference between the environmental attitude of village and city children could be reduced, in our opinion, even though in our research the distribution according to residence did not influence the willingness to use wood material in the future. According to Kónya (2018), the effectiveness of environmental education requires data acquisition (for example, studies) and clear identification of students' existing knowledge, knowledge gaps, feelings, and their willingness to act in the future (Kónya 2018; Conell et al. 1999).

We consider it important to encourage and strengthen the widespread of wood-based materials in the context of our proposals for the further use of our research regarding wood and wood use. Deepening the relationship with wood and encouraging today's young generation to fall in love with it is essential for developing environmentally-friendly behavior. The future generation's attitude towards the environment and environmental protection depends on us, the older generation, so we have a responsibility in the educational process. In this educational process, families must also take an active role in cooperating with the school. The upcoming generation must be aware of global and local environmental problems to preserve and improve the quality of life. According to the Hungarian National Basic Curriculum, all young people should strive to know their environment, recognize existing problems, perform actions to protect and preserve their environment, and prevent environmental problems (Nemzeti Alaptanterv 2021). Finally, from a statistical perspective, we deem our research seminal in that we used the framework of conditional inference trees, hitherto unemployed in silviculture research. Suggestions for further statistical analyses based on the raw data can be found in Fekete and Kendöl (2022).

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**Declaration of interest:** We have no conflicts of interest to report. All relevant ethical guidelines have been followed as well as the ethical principles for research involving human subjects in accordance with the Declaration of Helsinki (World Medical Association 2013).

**Data availability:** The data that support the findings of this study are openly available in the Figshare repository at https://figshare.com/projects/Assessing_attitudes_towards_wood_in_the_context_of_family_habits_a_large-scale_quantitative_study_in_Hungary/132230. Researchers must give us credit in the form of a citation, should they use or refer to the research object uploaded. Owner of the dataset is Jutka Nmarné Kendöl. The original questionnaire can be found on Google Docs: https://docs.google.com/forms/d/1jvQspylELSzGJjyDhZLmtIXhDguosDf8qIKF_90H3dA/edit

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**APPENDIX**

The Appendix contains a summary analysis of all the factor variables in the study. The numbers represent the number of observations per level of the factor in question.

*Table A. A summary analysis of all the factor variables in the dataset.*

| The factor variables in the questionnaire | | | |
|---|---|---|---|
| Gender | | | |
| | Boy | Girl | |
| | 230 | 200 | |
| | | | |
| Type of school the participant | | | |
| | Elementary school | High school | Secondary technical school |
| | 230 | 77 | 123 |
| | | | |
| The current living environment of the participant | | | |
| | City | Town | Village |
| | 267 | 104 | 59 |
| | | | |
| The environment the participant was raised in until the age of 12 | | | |
| | City | Town | Village |
| | 196 | 86 | 148 |
| | | | |
| If there someone in the family who works with wood as a professional | | | |
| | No | Yes | |
| | 321 | 109 | |
| | | | |
| Whether the participant would like to deal with wood as a professional later in his/her life | | | |
| | I don't know | No | Yes |
| | 116 | 250 | 64 |
| | | | |
| Whether the family heat with wood in the household | | | |
| | I don't know | With coal | With district heating |
| | 60 | 10 | 46 |
| | With gas | With other heating resource | With wood |
| | 164 | 20 | 130 |
| | | | |
| Whether the participant watches movies or documentaries related to wood | | | |
| | No | Yes, alone | Yes, with my parents |
| | 271 | 83 | 76 |
| | | | |
| Whether the family of the participant have trees in their garden | | | |
| | No | Yes | |
| | 65 | 365 | |

| | | | |
|---|---|---|---|
| | | | |
| When there is a family event, such as the birth of a child or a wedding, do they plant a tree? | | | |
| | I don't know | No | Yes |
| | 41 | 327 | 62 |
| | | | |
| Whether the participant plans to plant a tree in adulthood | | | |
| | I don't know | No | Yes |
| | 77 | 27 | 326 |
| | | | |
| If there is a wooden tool or piece of furniture in the family | | | |
| | I don't know | None | Yes, a few years |
| | 14 | 14 | 145 |
| | Yes, a lot | | |
| | 257 | | |
| | | | |
| How the participant would replace a destroyed or ruined wooden object or tool | | | |
| | I would replace it with other materials | I would replace it with wood | I wouldn't replace it |
| | 85 | 307 | 38 |
| | | | |
| What the participant would do with a broken wooden tool | | | |
| | I would burn it | I would throw it out | I would try to recycle it |
| | 116 | 65 | 249 |
| | | | |
| If there is a wooden tool in the family of the participant | | | |
| | No | Yes | |
| | 244 | 186 | |
| | | | |
| If there is an old wooden object in the family inherited | | | |
| | I don't know | No | Yes |
| | 160 | 67 | 189 |
| | | | |
| If the participant would choose a wooden piece of furniture later as an adult | | | |
| | I don't know | No | Yes |
| | 83 | 8 | 339 |
| | | | |
| If the participant has ever seen an old farmhouse from wood which one can still live in, or which can be restored | | | |
| | No | Yes | |
| | 85 | 345 | |
| | | | |
| If the participant has ever lived in a wooden farmhouse | | | |
| | No | Yes | |
| | 152 | 278 | |
| | | | |
| If participant finds that a wooden farmhouse is environmentally friendly | | | |

| | | | |
|---|---|---|---|
| | I don't know | No | Yes |
| | 169 | 115 | 146 |
| | | | |
| If the participant would build a wooden farmhouse | | | |
| | I don't know | No | Yes |
| | 114 | 162 | 154 |
| | | | |
| If the participant has ever taken part in a school program or school camp related to wood | | | |
| | No | Yes | |
| | 244 | 186 | |
| | | | |
| If participant has taken part in such as program, would they do it again? | | | |
| | I don't know | No | Yes |
| | 208 | 76 | 146 |
| | | | |
| If the participant has ever taken part in a program where some old wood-related profession was shown | | | |
| | No | Yes | |
| | 186 | 244 | |
| | | | |
| If the participant would like to attend a wood-related workshop at school | | | |
| | I don't know | No | Yes |
| | 137 | 183 | 110 |
| | | | |
| If participant has ever taken part in a school activity where wood was involved or burnt | | | |
| | No | Yes | |
| | 96 | 334 | |
| | | | |
| If the participant has ever attended a campfire program | | | |
| | No | Yes | |
| | 239 | 191 | |
| | | | |
| If participant has ever seen a TV program in which wood or traditions related wood were themes | | | |
| | No | Yes | |
| | 153 | 277 | |
| | | | |
| In the current location of participant, is there an old wood-related tradition currently? | | | |
| | No | Yes | |
| | 239 | 191 | |
| | | | |
| If participant plans to celebrate wood-related traditions in adulthood | | | |
| | I don't know | No | Yes |
| | 186 | 155 | 89 |
| | | | |
| Deforesting effect: participant had to answer if he/she thinks that their use of wood is affected by the knowledge/fact that trees are cut | | | |

| | I don't know | No | Yes |
|---|---|---|---|
| | 126 | 142 | 162 |

*Table A* illustrates the distribution of all ordinal variables in the dataset valid number of observations (*n*), mean, standard deviation of the mean (*SD*), median, minimum, maximum, and range.