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Research Article

Education for sustainable mobility in Slovenia: Using gamification to influence the travel habits of children

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Abstract: The ever-increasing mobility of modern society has a number of negative effects on space, the environment, health and quality of life. It is therefore crucial to raise awareness of the importance of sustainable mobility, part of which is effective and comprehensive education of children. The article presents some key findings of the Sustainable Mobility in Preschools and Primary Schools project, carried out in the period 2019–2021. We investigated whether gamified activities can change students' travel habits and whether the change in travel habits is influenced by their age. The study is based on the survey data from 28,043 primary school students (grades 1–9) across 220 schools (77.7% in rural, 22.3% in urban settlements). Employing paired-samples t-tests and one-way analysis of variance, the study evaluated the impact of gamified activities on travel habits. The results show that children can significantly change their travelling habits with the help of gamification. Although the greatest change in travel habits occurred during the implementation of the activity, the results suggest that more lasting effects can also be achieved. Furthermore, younger participants displayed greater responsiveness to the gamified interventions compared to their older counterparts. This research enhances the corpus of knowledge pertaining to educational strategies for sustainable mobility by providing insights from one of the largest projects to investigate the influence of gamified activities on children's commuting habits.

Keywords: sustainable development; sustainable mobility; travel habits; primary school students; education; gamification.

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Highlights:

- More than 28,000 primary school students from 220 schools participated in the research.
- Gamification can be used for promotion of sustainable mobility among students.
- During the gamified activity, the share of sustainable journeys increased by 20,87 percentage points
- Success of gamified activities depends on the age of students
- Younger children were the most receptive to the gamified activities

1. Introduction

Sustainable development has become a central theme in modern society, as we become aware of the need for long-term sustainability of natural resources, of the environment, and of social progress (Biancardi et al., 2023; Piao & Managi, 2023). Sustainable development is also becoming increasingly important in education (Brkić-Vejmelka et al., 2022; Skou Grindsted, 2013). One of the key components of sustainable development is sustainable mobility, which focuses on the development and use of transport systems that are environmentally friendly, socially inclusive, and efficient in moving people and goods (Brůhová Foltýnová et al, 2020; Gallo & Marinelli, 2020). It is a response to an important development dilemma, arising on the one hand from the desire to ensure a high level of accessibility and mobility, and on the other hand from the desire to avoid negative impacts of mobility (traffic congestion, pollution, greenhouse gas emissions, and high energy consumption) (Bartzokas-Tsiompras & Photis, 2020; Bartzokas-Tsiompras & Bakogiannis, 2023; Ogrin et al., 2019; Otrin et al., 2013; Resnik Planinc et al., 2018).

Proliferation of sustainable mobility requires a change in people's mindset and the promotion of sustainable travel habits (Bruun & Givoni, 2015; Suchanek & Szmelter-Jarosz, 2019). Education and campaigns that promote awareness of the environmental and social impacts of transport, play a crucial role, since they contribute to changes in people's travel habits and behavior (Dėdelė & Miškinytė, 2021; Guglielmetti Mugion et al., 2018; OECD, 2002). Children are a key target group, as their mobility choices and habits will shape future mobility (Kelly & Fu, 2014; Mammen et al., 2014a; 2014b; Napier et al., 2011). Several successful projects have been launched in various countries in recent years with the aim of changing the mobility habits of children. Connect project, Living Streets – Walk Once a Week (Living Streets, 2015); the Walk or Bike to School (Sirard & Slater, 2008), the Walking School Bus (Smith et al., 2015), Let's Meet at the Station (Resnik Planinc et al., 2018), the Bike Train (Moening & Zimmerman, 2018), are just a few.

One approach to promoting sustainable mobility is gamified activities that combine fun with environmental awareness (Sipone et al., 2019). Teachers often notice the increasing passivity of students in the classroom and lack of motivation to learn, as many students perceive traditional lessons as ineffective and boring (Dicheva et al., 2015). Teachers therefore face many challenges in making the educational process appealing and interesting to engage students (Marentič Požarnik, 2022; Sund, 2016). As a response to this dilemma, the concept of gamification has often proven to enhance students' motivation and desire to learn and develop important skills such as problem solving, interpersonal communication, and

collaborative learning (Apostol et al., 2013; Dicheva et al., 2015; Ilc Klun, 2022; Mogensen & Schnack, 2010; Wals, 2011). Arnold (2014) claims that by transferring elements of gamification to education, opportunities for learning are greatly increased. Manzano-León et al (2021) provide a systematic analysis of gamification systems used at different educational levels of formal education.

Gamification leverages game-based mechanics, aesthetics, and cognitive frameworks to actively engage individuals, incite action, facilitate learning, and address challenges (Kapp, 2012). This approach integrates elements and principles inherent in games into contexts outside traditional gaming scenarios (Deterding et al., 2011). As such, it formally and informally enhances motivation and learning processes. Key components encompass challenges, points, levels, badges, and user rankings, catering to a broad demographic from children to adults. While gamification shares the overarching objective of enhancing learning and engagement with other methodologies such as serious games (focused on targeted training objectives), game-inspired design (drawing upon game concepts), simulations (replicating real-world scenarios for training purposes), and entertainment-based games, it stands out for its diverse applications. Various types of gamification include educational gamification (targeting learning improvement), primary gamification (implemented in primary education settings), secondary gamification (utilized in secondary education contexts), and business gamification (aimed at boosting productivity and fostering creativity). Adding rewards and other incentives to the game can increase the motivation to play. Sometimes the elements of the game give students the feeling that they are not learning at all, and the teacher can use these elements to increase their level of activity and interest during the learning process. In this way, learning goals are accomplished without realizing it, and the teacher achieves better educational results. Carefully crafted enhancements to educational gaming platforms also foster the cultivation of critical thinking, creative problem-solving, and teamwork proficiencies (Renaud & Wagoner, 2011), thereby facilitating a notable 40% augmentation in skill acquisition capabilities (Zvarych et al., 2019). Gamification also has a downside. Toda et al. (2018) have identified four major negative effects associated with gamification and gamified learning design that are linked with them, namely indifference, loss of performance, undesired behavior, and declining effects.

Gamification, which includes the use of game elements in non-game contexts, can be used in promotion of sustainable mobility among students. Students often face challenges and obstacles when adopting sustainable modes of mobility (Stark et al., 2015; Su et al., 2013), and gamification can help overcome these obstacles by motivating and engaging them in an innovative, playful way. By encouraging healthy competition, cooperation, and achievement, it enables them to develop positive habits of sustainable mobility. Using elements of gamification, we can increase the knowledge and awareness of students regarding sustainable mobility options on the one hand, and in this way stimulate their interest in using environmentally friendly, sustainable means of transport on the other. Gamified activities allow students to actively engage in the process of changing their habits and participate in the creation of sustainable mobility options in their local environment. They also encourage social interaction among students, as they can be based on competitive and collaborative challenges, due to the rewards and incentives that students receive during gamified activities when they choose sustainable modes of mobility. This further motivates their involvement in sustain-able practices (Fonseca, 2023; Wang et al., 2022).

With the aim of increasing sustainable mobility of preschool and primary school students, and consequently contributing to the reduction of motor vehicle traffic in the vicinity of preschools and schools, the Ministry of Infrastructure of Republic of Slovenia launched the project Sustainable Mobility in Preschools and Primary Schools (hereinafter referred to as the Sustainable Mobility project) in 2019. The initiative constituted a segment of the Ministry of Infrastructure's endeavors aimed at fostering sustainable mobility within preschools and primary schools. The initiative's demographic focus included children, preschool educators and assistants, primary school students and their teachers.

The project's objective was to alter the habits and behaviors of children, which inevitably influenced the habits and behaviors of their parents, caregivers, educators, and teachers. Consequently, it became imperative to acknowledge that behavior change is driven by individuals' goals. Therefore, any interventions designed to modify individual behavior should be in harmony with existing goals or should modify them to render the desired behavior the most rational choice from the individual's standpoint in any given circumstance. To accomplish this, either the external situation or the internal patterns of perception, evaluation, and coping must be transformed. Typically, a combination of strategies is more effective than attempting to change only one aspect of the situation-person interaction loop. Mental shifts make people more receptive to situational changes and the pressures they exert on behavior. Conversely, situational changes solidify new mental patterns if they prove more advantageous for the individual. As long as the disparity between personal goals and situational reality persists, individuals will seek to modify the situation when possible since constellations where preferences align with the situation are more enduring (Duckworth & Gross, 2020; Flury-Kleubler & Gutscher, 2001; Heimlich & Ardoin, 2008; Molina-García et al., 2020).

The project's primary activity was called Let's walk with Rosie the Chicken (hereinafter referred to as Let's walk!). The activity aimed at promoting sustainable commuting among primary school students, aged six to fourteen, encompassing grades 1 through 9. It primarily advocated for modes of transportation such as walking, cycling, or utilizing scooters, rollerblades, or skateboards for commuting to and from school. However, journeys undertaken via school bus or public transportation were also seen as sustainable within the activity context. The project also aimed to promote children's physical activity, and thus improve their health.

The Let's Walk! activity spanned a week, from Monday to Friday, wherein students reported their chosen mode of transportation to school daily. The number of students opting for sustainable transportation was documented on a class poster, allowing for the calculation of the percentage of sustainable journeys each day. On the final day, classes were awarded gold, silver, or bronze medals based on their progress or overall percentage of sustainable journeys. In schools with multiple participating classes, sustainable journey data was also aggregated on a school-wide poster to foster inter-class competition. Individual students were incentivized for sustainable commuting by receiving game cards each time they utilized sustainable transportation methods. These cards granted access to various pre-designed games, including an educational board game aimed at promoting awareness and understanding of sustainable mobility and fostering sustainable competencies.

Throughout the implementation of the Let's Walk! activity, teachers were encouraged to incorporate sustainable mobility discussions into their lessons. A comprehensive teacher's handbook was developed to heighten students' awareness regarding the significance of walking, cycling, and utilizing public transportation in daily life. This handbook, grounded in Slovenian school practices, is aligned with the primary school curriculum and offers diverse content on sustainable mobility tailored to different age groups and learning formats. For access to the handbook, refer to Ogrin et al. (2019).

The paper examines 1) the effectiveness and impact of gamified activities in promoting sustainable mobility among students, and 2) the influence of gamified activity on changing their travel habits. We are interested in whether the gamified activities that we carried out among the primary school population as part of the project could 1) influence the travel habits of students (H1: Travel habits of students change due to the implementation of gamified activities by at least 15% in favor of sustainable mobility) and, in the continuation, 2) whether the change in travel habits is influenced by the age of the students (H2: Younger students are more susceptible to the effects of gamified activity than older students).

Specifically, we assume that the gamified activities that we planned as part of the project activities Let's walk! are effective primarily for the youngest students, while for slightly older primary school students (the second and third three-year periods), different forms of gamified activities (e.g. connected with mobile phone apps) promoting sustainable mobile habits might be more suitable.

2. The sample data & methods

A total of 63,698 students aged 6 to 14 from 314 primary schools participated in the project in the 2019–2021 period. All students in-volved in the Let's walk! activity participated in three surveys. In the first survey (hereinafter referred to as the initial survey), carried out before the start of Let's walk! activity, we obtained data on students' existing daily travel habits. We were interested in how students usually travel to school. The second survey (hereinafter referred to as the interim survey), carried out during the project Let's walk! activity, asked students about their travel habits during the activity. They had to record the way they arrived at school every day for one week. We were interested in whether students changed their travel habits due to targeted education and gamified activities in favor of sustainable mobility. With the third survey (hereinafter referred to as the follow-up survey), we wanted to find out what students' travel habits were after a certain amount of time had passed since the end of the activity. The follow-up survey was conducted a few months after the end of the project activities. Students were asked to record the way they got to school for a week, during which teachers did not encourage them to use sustainable ways of getting to school. For analysis, the data were aggregated at the class level. Only classes that had participated in all three surveys were included in the analysis. A total of 1,381 classes and 28,043 students from 220 schools were included, which represents just under half the students who participated in the activity.

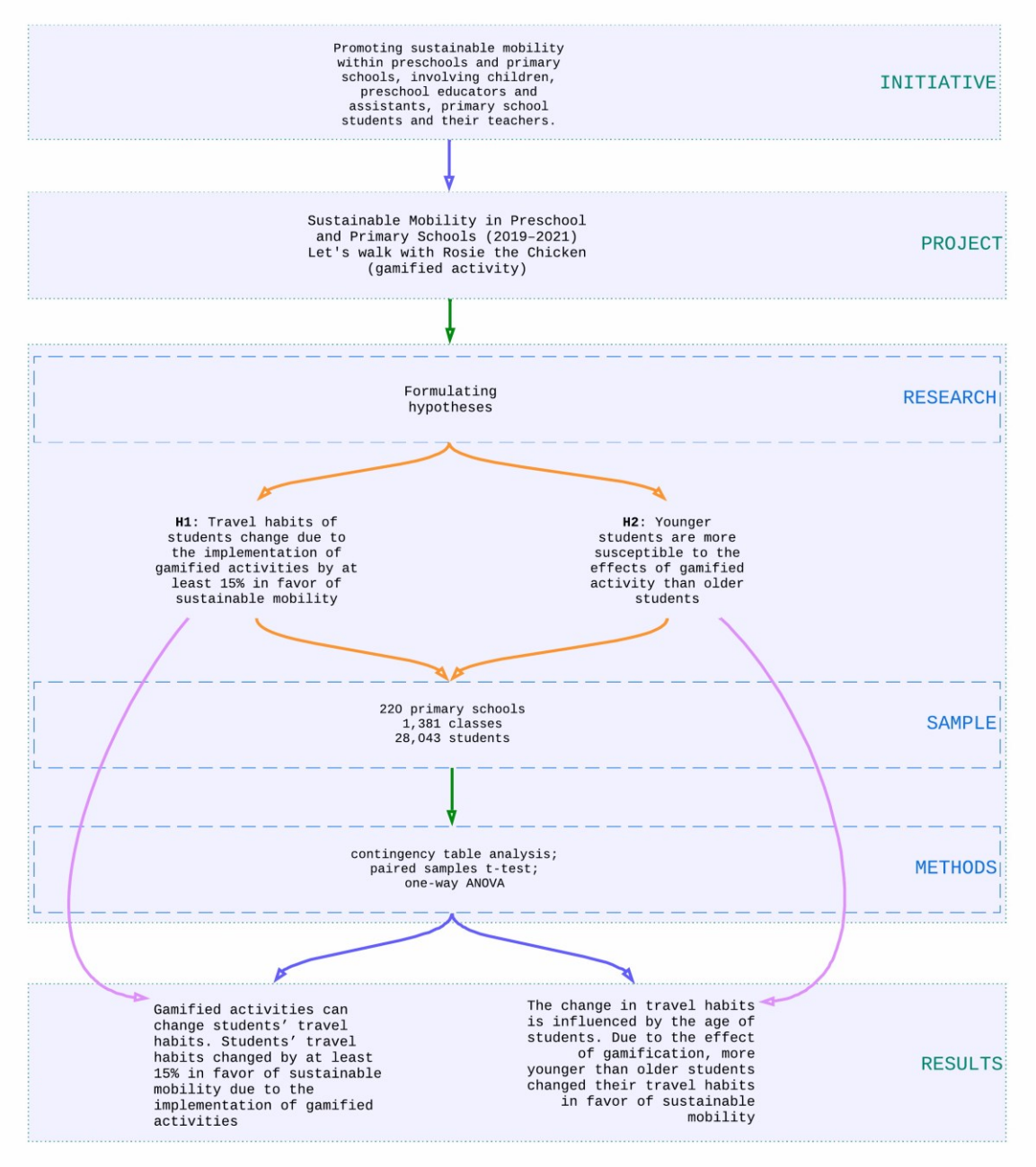

Figure 1. Flowchart of the research

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To mitigate the impact of weather conditions, it was recommended that schools conduct the activity during weeks characterized by favorable weather. Most schools opted to implement the activity during early autumn or spring seasons, characterized by moderate temperatures and low to moderate forecasted precipitation.

Primary education in Slovenia is universally accessible due to an extensive network of primary schools comprising 456 central and 315 branch public institutions, ensuring geographical proximity for all students. Each primary school is assigned a defined school district by local authorities. Within our survey, the average size of these school districts was 27.5 km² (with a median of 21 km²), ranging from as small as 0.4 km² to over 230 km² (Figures 2 and 3). Predominantly, these school districts are situated in rural villages (77.7%), with a minority located within urban areas (22.3%). Approximately 32.6% of the districts exhibit relatively flat terrain, characterized by an average slope of less than 5° and an average elevation of 269.2 meters above sea level. Conversely, 29.5% of districts feature steeper terrain, with an average slope exceeding 10° (maximum slope observed: 27.5°) and an average elevation of 608.3 meters. The surveyed school districts are distributed across various surface types, with a majority situated in valleys, basins, or plains.

Parents typically enroll their children in the primary school located within the district of their residence. Collaboratively, the municipality and schools coordinate free transportation services for students residing more than four kilometers away from the school. However, irrespective of distance, students in grade 1 are entitled to free transportation, and in other grades, if the competent road traffic authority deems the student's safety to be jeopardized during the commute to school (Zakon o osnovni šoli, 2016).

The distance between a student's home and school significantly influences their choice of transportation method. To safeguard personal data, we abstained from collecting specific residential locations, with students instead providing self-estimations of commuting distances (Figure 2 and 4). The histogram of the students' travel distance to school is presented in Figure 4. The average travel distance to school is 2.6 kilometers, although the median distance is around 1.5 kilometers. The data show that around 50% of students travel less than 1.5 kilometers to school and more than 75% of them travel less than 3.5 kilometers, which is ideal for sustainable mobility. Although there are also students who travel more than 10 kilometers to school (the longest recorded commute is 61 kilometers), such a commute is exceedingly rare.

The geographical location of the school districts influences the distance traveled. Notably, smaller school districts are typically situated in areas with higher population density, resulting in shorter estimated distances to schools. Conversely, larger districts, predominantly found in sparsely populated mountainous regions, often feature longer distances, although these distances are not excessively vast due to uninhabited higher-altitude areas within these districts. The most significant commuting distances were observed in medium-sized and mountainous districts with modest population distributions throughout the entire area (Figure 2). It is important to note that student estimations of commuting distances may contain inaccuracies.

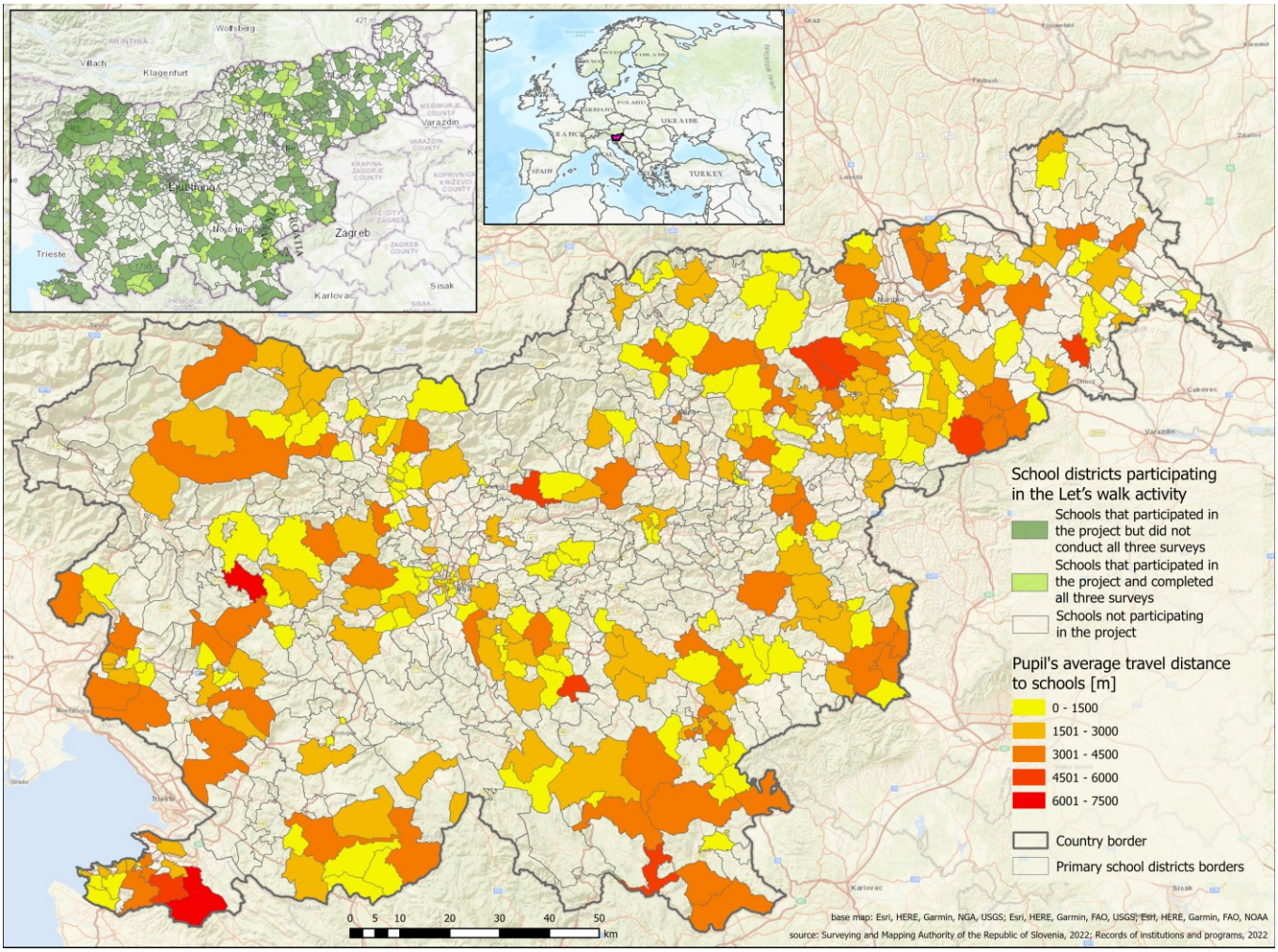

Figure 2. Distribution of the school districts participating in the project and students' average travel distance to school

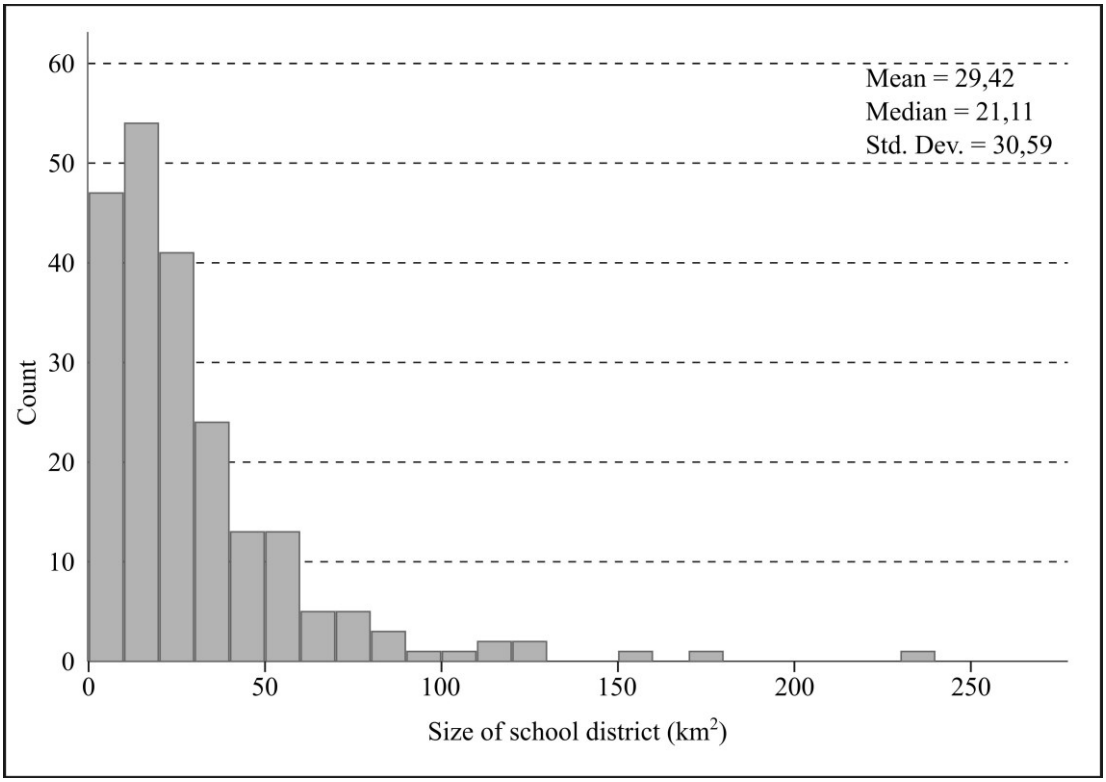

Figure 3. Histogram of the size of school districts actively participating in the project

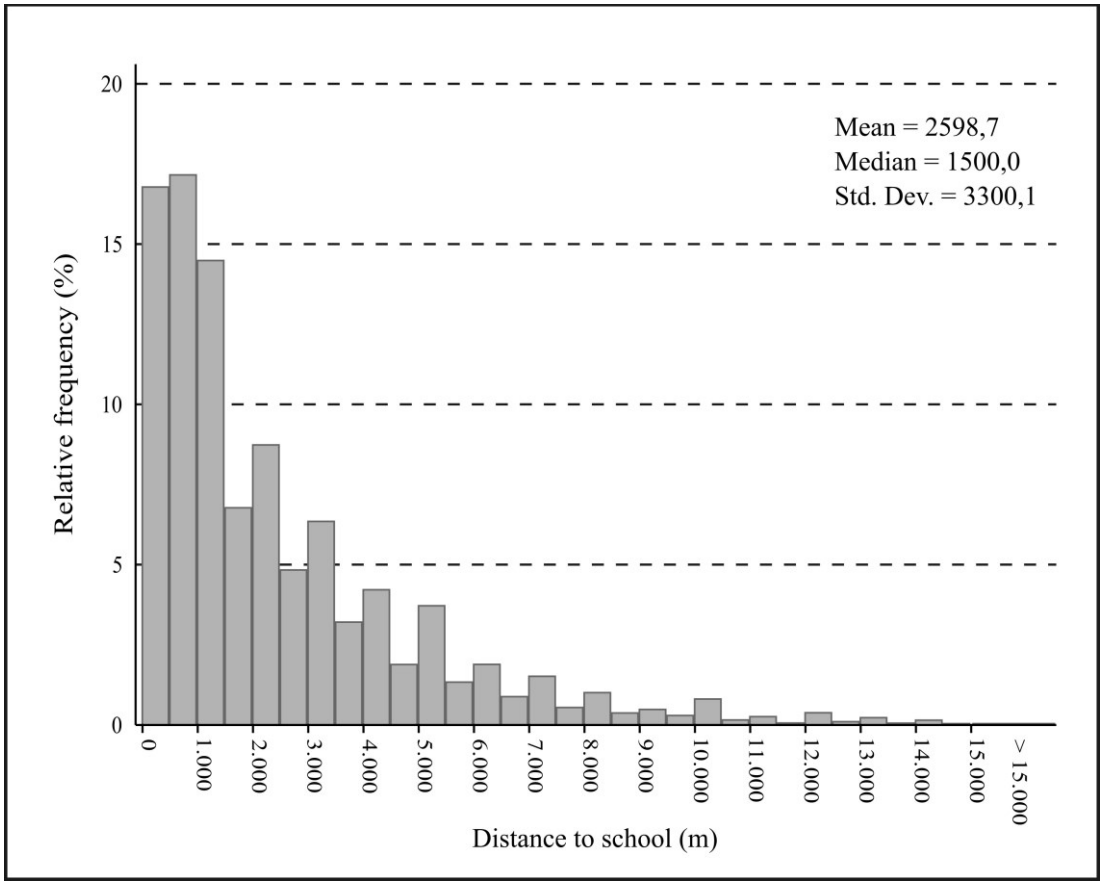

Figure 4. Histogram of the students' travel distance to school

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The age composition of students is presented in Table 1. The largest number of students included in the study were students in the first three grades (grades 1–3). Two reasons likely contributed to this: the design itself of the project activities, which was more suited to younger students, and the easier implementation of the activities at the lower grades level (grades 1–5), when one teacher teaches one class all or at least most of the subjects and can thus more easily include cross-curricular content relating to sustainable mobility in the educational process.

Table 1. Number of classes and students included in the analysis.

Grade	Number of classes	Number of students	Percentage of students (%)	Average number of students per class	Number of classes in the group	Number of students in the group	Percentage of students (%) in the group	Average number of students per class in the group
1	203	4,170	14.9	20.54	614	12,513	44.6	20.4
2	200	4,048	14.4	20.24				
3	211	4,295	15.3	20.36				
4	189	3,867	13.8	20.46	475	9,639	34.4	20.3
5	178	3,649	13.0	20.50				
6	108	2,123	7.6	19.66				
7	115	2,338	8.3	20.33	292	5,891	21.0	20.2
8	109	2,196	7.8	20.15				
9	68	1,357	4.8	19.96				
Total	**1,381**	**28,043**	**100.0**	**20.31**	**1,381**	**28,043**	**100.0**	**20.3**

In all three surveys, we utilized the modes of mobility recommended by the Ministry of Infrastructure and employed in previous similar projects: 1) on foot or using feet (including scooters, skates and skateboards); 2) by bike; 3) by school bus or van; 4) by public transport; 5) by car and 6) other (this category includes other forms of arrival at school (like e-bikes, e-scooters, motor scooter,…), a combined method of arrival at school, category unknown and category absent). The first four modes were categorized as sustainable journeys.

For all classes, for each survey we calculated the share of students in the class who used a sustainable type of mobility (variable Share of sustainable journeys in class). In the initial survey, the Share of sustainable journeys in class based on the number of students who stated that they almost always come to school in a sustainable way. In the interim and follow-up surveys the Share of sustainable journeys in class based on the number of students who came to school in a sustainable way at least four times during the week the survey was carried out.

The influence of weather on students' travel habits was examined only for the interim survey. The contingency table analysis was used to study the influence of weather on modes of mobility.

The impact of the implementation of the activity on changing the travel habits of students (H1: Travel habits of students change due to the implementation of gamified activities by at least 15% in favor of sustainable mobility) was tested using a paired samples t-test. We compared the Share of sustainable journeys in class in the initial, interim and follow-up surveys. We were interested in whether there were statistically significant differences in the proportions between the three conducted surveys.

The dependence of changing students' travel habits on the age of students (H2: Younger students are more susceptible to the effects of gamification than older students) was tested using one-way ANOVA. Due to large differences in group size and inhomogeneous variances, Welch (FW) and Brown-Forsyth (FBF) F statistics and Games-Howell post-hoc analysis were used. The participating classes were grouped into three categories according to three three-year periods in primary education. Grades 1–3 (students aged 6–8 years) composed the first group, grades 4–6, (students aged 9–11 years) composed the second group, and the third group included grades 7–9 (students aged 12–14 years).

3. Results

Analysis of the weather data in Table 2 indicates that the schools followed our advice and carried out the activity in a week with favorable weather conditions. Over 127,500 journeys were recorded during the Let's walk activity, but only 14.2% of these took place in the rain (Table 2). It is noticeable that when it was raining, the proportion of journeys made on foot or by bike fell significantly and the proportion of car journeys rose sharply. The proportion of the former fell from around 60% to below 50% and the proportion of the latter rose from under 20% to almost 30%.

A comparison of the Share of sustainable journeys in the class (Figure 5 and Table 3) shows a clear change in travel habits during and after the activity. The lowest share was recorded in the initial survey (M = 52.34%, SE = 0.61) and the highest in the interim survey (M = 73.21%, SE = 0.44). The follow-up survey indicates a decline (M = 64.34%, SE = 0.54). The results of the paired samples t-test show a statistically significant increase in the share both between the initial and interim survey ($t(1380) = 37.230$, $p < 0.001$) as well as between the initial and follow-up survey ($t(1380) = 25.554$, $p < 0.001$). For the former the effect size, as measured by Cohen's d, is d = 1.00, indicating a large effect. For the latter the Cohen's d indicates medium effect size (d = 0.69). As expected, there was a decline in the share of sustainable journeys to school between the interim and follow-up surveys ($t(1380) = -16.659$, $p<0.001$). The effect size is small (d = 0.45).

Table 2. The impact of weather on mode of mobility during the Let's walk activity

		Weather							
		sunny	%	cloudy	%	rainy	%	**Total**	**%**
Mode of mobility	on foot	32,936	60.1	32,081	58.7	8,922	49.3	**73,939**	**58.0**
	by bike	2,550	4.7	2,195	4.0	231	1.3	**4,976**	**3.9**
	by school bus or van	8,688	15.9	8,948	16.4	3,112	17.2	**20,748**	**16.3**
	by public transport	1,244	2.3	1,417	2.6	510	2.8	**3,171**	**2.5**
	by car	9,339	17.1	10,026	18.3	5,318	29.4	**24,683**	**19.4**
	Total	**54,757**	**100.0**	**54,667**	**100.0**	**18,093**	**100.0**	**127,517**	**100.0**

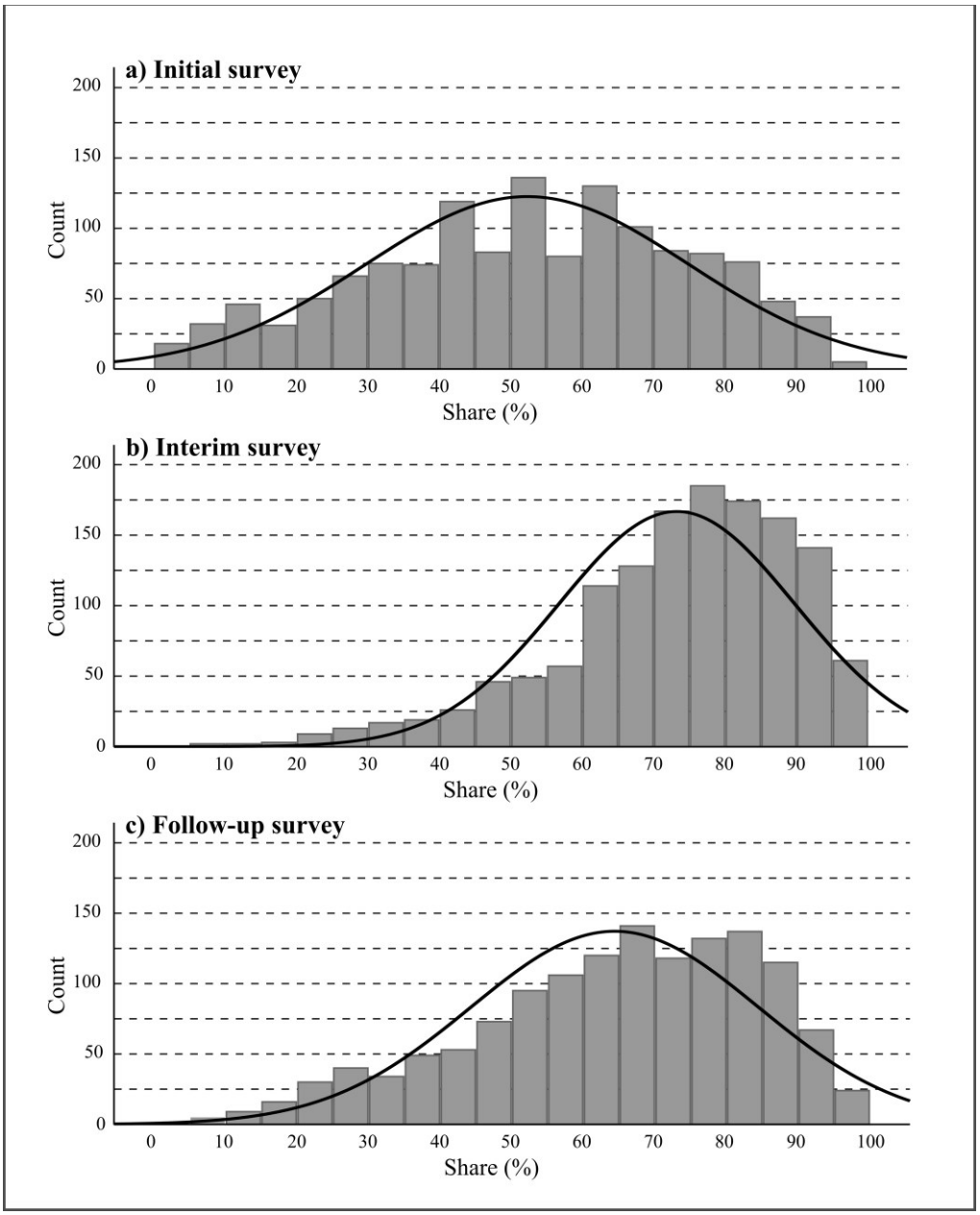

Figure 5. The share of sustainable journeys in classes in: a) initial survey; b) interim survey; c) follow-up survey

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Next, we checked the dependence of the change in travel habits on the age of the students (H2: Younger students are more susceptible to the effects of gamification than older students). One-way ANOVA analysis confirmed the existence of statistically significant differences in the Share of sustainable journeys between three age groups of students (6–8 years, 9–11 years, 12–14 years) in all three surveys. The results of the one-way ANOVA are presented in Table 4. Post-hoc analysis showed statistically significant differences between all pairs of the Share of sustainable journeys except between the second and third age groups in the interim survey.

The lowest share of sustainable journeys in all three surveys was recorded by classes in grades 1–3 (Table 3), although this group saw the greatest growth in sustainable journeys during the implementation of the activity. Compared to the initial survey, the average increased by 27.68 percentage points. At the same time, it is also worth noting that this age group also recorded the largest decline in sustainable journeys after the end of the activity (the average decrease was 13.36 percentage points). The second group (grades 4–6) recorded the highest proportion of sustainable journeys in the interim survey. The decline in the share of sustainable journeys was smaller in this age group than in the first group (6–8 years) but greater than in the third (12–14 years). The third group (grades 7–9) showed the highest share of sustainable journeys in the initial and follow-up surveys. However, this group had the smallest changes in the share of sustainable journeys.

Table 3. Descriptive statistics for the variable *The share of sustainable journeys* in grades broken down by age group.

Survey	Age group	Mean	Std. error of the mean	Median	Std. deviation
Initial survey	Grades 1–3 (6–8 years)	40.50	0.87	40.00	21.66
	Grades 4–6 (9–11 years)	59.24	0.84	60.87	18.34
	Grades 7–9 (12–14 years)	66.03	1.05	68.18	17.91
	Total	52.34	0.61	52.94	22.58
Interim survey	Grades 1–3 (6–8 years)	68.18	0.76	71.23	18.95
	Grades 4–6 (9–11 years)	77.69	0.60	79.00	13.11
	Grades 7–9 (12–14 years)	76.47	0.74	77.50	12.67
	Total	73.21	0.44	76.00	16.52
Follow-up survey	Grades 1–3 (6–8 years)	54.82	0.82	56.52	20.30
	Grades 4–6 (9–11 years)	70.45	0.78	72.94	17.01
	Grades 7–9 (12–14 years)	74.40	0.87	76.59	14.82
	Total	64.34	0.54	66.96	20.08

Table 4. Results of one-way ANOVA analysis for three age groups.

survey	F statistic	F	df1	df2	p.
Initial survey	F_W	204.159	2	787.9	<0.001
	F_{BF}	222.436	2	1243.8	<0.001
Interim survey	F_W	51.539	2	816.5	<0.001
	F_{BF}	64.261	2	1311.6	<0.001
Follow-up survey	F_W	155.831	2	818.1	<0.001
	F_{BF}	173.934	2	1324.3	<0.001

4. Discussion

Results of the analysis confirm both hypotheses, as we showed that 1) gamified activities can change students' travel habits (students' travel habits changed by at least 15% in favor of sustainable mobility due to the implementation of gamified activities) and that 2) the change in travel habits is also influenced by the age of students (due to the effect of gamification, more younger than older students changed their travel habits in favor of sustainable mobility).

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The substantial increase in sustainable journeys during the activity's implementation is not surprising, since the main purpose was to encourage students to come to school in a sustainable way. It should be noted that the results of the follow-up survey and the high shares of sustainable journeys were influenced by two factors. The first is the impact of conducting the survey on travel habits. We assume that some of the students changed their travel habits mainly due to the recording of journeys for the needs of the follow-up survey, although they usually do not come to school in a sustainable way and the teachers did not encourage them to use sustainable ways of getting to school. The second factor relates to sample data. The implementation of the mentioned activities required a certain amount of effort and commitment from the teachers. As a result, it is reasonable to conclude that the analysis includes data from those classes whose teachers were very motivated and engaged in the implementation of project activities (3,327 classes with 58,571 students participated in the initial survey, but only 1,381 classes with 28,043 students participated all three surveys). We can assume that these teachers more actively encouraged students to change their travel habits and use sustainable modes of transport even after the conclusion of the project.

The lowest share of sustainable journeys in grades 1–3 (Table 3) is understandable, as students in Slovenia up to the age of 7 must be accompanied by older persons (most often parents or guardians) when coming to school. The way of getting to school is therefore much more dependent on companions in this group than in the other two age groups. It is interesting that this group saw the greatest growth in sustainable journeys during the activity's implementation. This shows the great power and impact of gamified activities on learning and changing travel habits in this age group. Teachers of younger students found it easier to implement project activities in their existing educational programs, since one teacher teaches most of the subjects in the class, and in addition, gamified forms of activity were probably more motivating for the younger students. The reasons for the largest decline in sustainable journeys after the activity's end are the previously described dependence of students on chaperones when coming to school in this age group.

The main reason for the highest share of sustainable journeys in the initial and follow-up surveys in the third group (grades 7–9) can be found in the greater independence of students in this age group, or less dependence on chaperones. The smallest changes in the share of sustainable journeys in this group can be linked to the lower power and role of gamified activities in changing the travel habits of older students. It is important to note, however, that in this age group there was the smallest decline in the share of sustainable journeys after the end of the activity (amounting to only two percentage points).

The highest proportion of sustainable journeys in the second group is also not surprising, since students in this age group are less dependent on chaperones when they come to school, and at the same time they are still receptive to the incentives they received through gamified activities.

Our analysis has some important limitations. In the survey the students were not asked about their socio-economic status. Socio-economic indicators would certainly build on our findings and provide better insights into the background of their response to gamification and the resulting behavior in favor of sustainable mobility. Previous studies have shown that demographic factors, external factors (e.g. institutional, economic, social and cultural) and internal factors (e.g. motivation, pro-environmental knowledge, awareness, values, attitudes, emotions, etc.) have important impact on pro-environmental behavior (Kollmuss & Agyeman, 2002). For example, research confirms the connection between social factors and physical activity among adolescents, as high family income and a high level of parental education are positively related to the levels and types of physical activity among adolescents (Kantomaa et al., 2007).

It would also make sense to include parents in the research, since they play a critical role in raising and encouraging their children in learning about traffic and travel habits. We therefore believe that the involvement of parents in school campaigns and promotional and educational school events relating to sustainable mobility is highly recommended, if not indeed essential.

Another key factor that was left out in our analysis is the safety of the traffic infrastructure, especially the safety of walking and bike lanes (Gössling, 2020). To increase the number of children walking or cycling to school in the future, it is first and foremost necessary to ensure a higher level of traffic safety on school routes and to take a holistic approach to the planning and systematization of cycling infrastructure and footpaths in school districts (Ewing & Cervero, 2010; Popovič, 2022; Strah, 2016).

Given that the activity only lasted for a limited time, the question arises as to what effects could be achieved by the activity if it were a regular practice in the Slovenian educational system. Through this activity, would we be able to influence the highly motorized and auto centric habits to a more sustainable one (Talmage & Frederick, 2019)? In order to be able to answer this question, the effects of activities should be measured over a longer time interval, which currently exceeds the scope of our research, but this is certainly a starting point for further research in the field of sustainable mobility of children in Slovenia.

Studies have shown that the attitude of young people towards the environment can be influenced. Gifford and Sussman (2012) thus claim that pro-environmental attitudes change based on current events, and at the same time vary according to age, gender, socioeconomic status, religion, values, personality, education, etc. Various theories have also attempted to explain the gap between having environmental knowledge and environmental awareness and displaying environmentally oriented behavior (Kollmuss & Agyeman, 2002) proving the extreme complexity of pro-environmental behavior. To catalyze the transformation of pro-environmental attitudes into behavioral intentions among young individuals, the emotional, functional, and relational values they hold are paramount (Ng & Cheung, 2022). Consequently, interventions fostering a positive attitude towards the environment are highly desirable as they incentivize environmentally friendly behaviors (Cayolla et al., 2023). At the same time, it is imperative to promote teaching practices that encompass the utilization of materials, institutional support, and didactic resources geared towards nurturing environmental attitudes, skills, and values in students (Díaz Grijalva et al., 2021). Baur and Haase (2015) further advocate for the efficacy and promise of an active participation and organization approach, wherein students collaboratively design and execute activities under the guidance of their teacher. Considering these findings, it is evident that students' engagement in activities is a pivotal factor in shaping their environmental behavior.

5. Conclusions

The article examines whether gamified activities conducted among primary school students can change their commuting travel habits to and from school and whether the age of the students influences the effectiveness of gamified activities. The results of a 2015 study (Resnik Planinc et al., 2018) prompted us to design a new activity that would engage as many primary school students as possible and would motivate children to change their existing, unsustainable travel habits. To achieve these goals, we developed a different and innovative gamified activity that is adapted to the Slovenian school system, considers the specifics of Slovenian mobility culture and can become established among students in schools to such an extent that it becomes part of standard practice in education, especially in education about sustainable mobility. To popularize sustainable

mobility, we named the activity Let's walk!, and chose Rosie the chicken as the main character, who encouraged students to get to school in a sustainable way.

The activity was based on the belief that children are naturally curious and playful and like to participate in various activities, and that gamification of education can increase the level of engagement of students, just as games can improve their specific skills and optimize their learning (Smiderle et al., 2020). Gamified activities take advantage of their natural inclination to play and have fun and interweave it with learning and awareness about sustainable mobility. Participation in games and game-related educational activities also allows them to learn about the environmental aspects of transport in an interactive and inclusive way. Through gamified activities, they not only acquire knowledge about sustainable mobility, but also develop responsibility, cooperation and a positive attitude towards the environment.

The results of this study indicate that through effective education, which includes elements of gamification within the formal education system, we can influence change in students' travel habits, which has already been confirmed by some research in the past (Abou-Zeid & Fujii, 2015; AST, 2024; Ben-Elia & Ettema, 2011; Coombes & Jones, 2016; HAST, 2024; Marucci et al., 2016; Yen et al., 2019). The biggest change in travel habits took place during the implementation of the activity, when the teachers encouraged students to come to school in a sustainable way every day and when they were also encouraged to do so by the gamified activity, but the results of the research show that we can also achieve lasting effects through short activities, such as Let's walk!. The results also indicate that gamified activities that we included in our project are effective primarily for the youngest students, while for slightly older primary school students (the second and third three-year periods), different forms of gamified activities (e.g. connected with mobile phone apps) promoting sustainable mobile habits might be more suitable. Our research supports the findings of similar studies that gamification is not expected to be effective in and of itself, but rather various game elements trigger various motivational responses (Sailer et al., 2017). We can claim based on the results of our research that it can inspire more sustainable travel habits, which we can hope will last into adulthood.

Our research contributes to the existing body of knowledge in the field of education for sustainable mobility. To the best of our knowledge this was one of the largest projects to measure the impact of gamified activities on children's commuting habits. A total of 28,043 students from 220 primary schools from different parts of Slovenia took part in the project. The inclusion of geographically and socio-economically diverse milieus in the study makes the results even more meaningful.

The authors acknowledge that encouraging students to change their travel habits through gamified activities is just one way to promote sustainable mobility and one of many steps to change people's mobility habits. Modern society is increasingly mobile and, as a result, also increasingly motorized, which is a cause for concern. Children are a large and important population group in mobility, as they rely on walking, cycling, public transport and being transported by car by their parents or guardians. The fact is that people's habits, which are instilled into us in childhood, are carried into adulthood, and this is true also of patterns of travel habits (Lioret et al., 2020; OECD, 2002). If children learn at an early age that the car is the safest, most comfortable and most efficient means of transport to travel even short distances, they will carry these habits into adulthood. And vice versa: if we show them through our example and with the support of effective upbringing and education that they can use sustainable means of transport (walking, bicycle, scooter, skateboard, bus, etc.) to cover everyday short distances (to and from school), then they will more likely carry this pattern and these habits into adulthood and will use such ways of traveling distances on a daily basis (OECD, 2004; Resnik Planinc et al., 2018).

The gamified activity also tried to raise and educate children to become active and responsible citizens who will be aware of the im-portance and advantages of using sustainable means of transport to preserve the quality of the environment as well as maintain their own health (Ogrin et al., 2019). We should not neglect the fact that regular physical activity contributes to the physical, mental and social health of children and adolescents (Grøntved et al., 2016; Kantomaa et al., 2007; Skayannis et al., 2017). Sustainable mobility, especially walkability and biking can also enhance children's spatial knowledge and navigation skills (Moran et al., 2017).

Our study did not explore the potential influence of parents, grandparents, guardians, and teachers on altering students' travel habits. Investigating this aspect would be valuable, as adults undeniably wield significant influence over children's travel behaviors through their own actions. Furthermore, it would be beneficial for future research to examine how all individuals directly (e.g. teachers, teaching assistants) or indirectly (e.g. parents, grandparents, guardians) associated with the school community can impact students' travel habits toward sustainable mobility, in addition to the school's initiatives promoting such behaviors. Several schools participating in our survey have chosen to engage the entire school community (students, teachers, parents, guardians, grandparents) in the "Let's Walk!" activity, fostering collective efforts to instill sustainable habits in children and induce changes in their travel behaviors.

Given that our prospects hinge on present actions, we encourage all stakeholders to utilize their time, expertise, and knowledge to foster healthier lifestyle habits among children.

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