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Acceptance of an online cycling training for adults to master complex traffic situations

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ABSTRACT

Introduction: The promotion of cycling as a sustainable and healthy mode of transport is often hindered by safety concerns. Cycling safety is influenced by various factors, such as infrastructure, traffic conditions, and cycling skills. Online cycling training is a scalable method for improving safety skills, but its effectiveness is ultimately determined by users' acceptance and usage intentions of the intervention.
Methods: This study uses a survey approach to investigate the usage and acceptance of an online cycling training intervention for adults, employing the Unified Theory of Acceptance and Use of Technology (UTAUT2) as theoretical framework. The training consisted of three modules designed to train cycling skills in seven traffic situations – such as recognizing priority, appropriate lateral position along parked cars, and recognizing blind spot situations. Out of 10,000 invitees, 1182 individuals completing module 1, and 708 individuals completing the entire training as well as answering to a survey to measure acceptance.
Results: Findings showed that frequent cyclists were significantly more likely to complete the entire training. Overall, acceptance ratings were generally high, with effort expectancy (ease of use) receiving the highest ratings, while the performance expectancy (perceived learning effect) was rated the lowest. Key factors associated with participants' intention to continue or participate anew in the training included hedonic motivation (fun), perceived learning benefits, price value (attractive prizes). Participants' cycling frequency moderated these effects.
Conclusion: This study's results indicate that a considerable share of cyclists is willing to complete an online cycling training. To enhance its reach, the training should appeal to both intrinsic motivation (enjoyment, learning benefits) and extrinsic motivation (prizes). Additionally, targeted measures are recommended to effectively address infrequent cyclists.

1. Introduction

The promotion of cycling is important as it provides an effective solution to key societal challenges, including environmental pollution, road congestion, and public health issues. In particular, the negative health effects of a sedentary lifestyle provide a

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compelling reason to motivate people to use their bicycles instead of motorized transport. Cycling is inherently a health-promoting activity, contributing to physical activity, mental well-being, and sustainable mobility (De Hartog et al., 2010; Kelly et al., 2023; Oja et al., 2011). However, safety concerns can discourage people from cycling (Winters et al., 2011). Therefore, ensuring cyclists' safety has become a critical concern for policymakers, urban planners, and public health officials (International Transport Forum, 2018; World Health Organization, 2020).

Cycling safety is influenced by a complex interaction of road infrastructure, human factors, and vehicle characteristics (Useche et al., 2018). While each of these components plays a crucial role for the overall safety of cyclists, the present study focuses on human factors and their potential contribution to cycling safety (Hakkert and Gitelman, 2014).

An established intervention to improve road users' safety by addressing human factors is awareness campaigns to increase safety knowledge or training safety skills (Assailly, 2017). However, conventional awareness campaigns often fall short of the expected impact because providing information does not necessarily lead to behavior change (Roaf et al., 2024; Wallius et al., 2022). Another intervention to improve cycling safety is in-situ training (Mandic et al., 2018; Sersli et al., 2019). However, trainings can only reach a small part of the target audience as they are designed for smaller groups, are expensive and require participants to travel to the training location, which may conflict with their schedules.

The limitations of conventional road safety programs necessitate novel and more engaging approaches to improve traffic safety. Serious games and online training methods have gained attention in the context of transportation safety, offering several advantages over traditional training approaches (Wallius et al., 2022). Online educational training is more convenient to participate in and, therefore, has the potential to reach a broader audience. A further advantage is the possibility of adding gamification to motivate participation in the training. Thereby, gamification is defined as the use of "game design elements in non-game contexts" (Deterding et al., 2011, p. 9). Gamification elements comprise competitions, badges, feedback, or rewards. The addition of gamification elements can increase engagement with educational content, support the learning process and thus promote actual behavior changes (Wallius et al., 2022). Gamification has been applied across various domains, particularly in the domain of education, learning, health, and psychology (Hammady and Arnab, 2022; Koivisto and Hamari, 2022). In the domain of transportation, gamification has been successfully implemented to promote active mobility (Roaf et al., 2024). To promote traffic safety, gamification has been used across various domains, including driver, pedestrian, aircraft passenger, and cyclist safety (Wallius et al., 2022). The effect of gamification on learning is frequently explained through Self-Determination Theory (SDT) (Hammady and Arnab, 2022; Ryan et al., 2006; Sailer and Homner, 2020). SDT provides a psychological framework for understanding how gamification can enhance intrinsic motivation by fulfilling basic psychological needs for autonomy, competence, and relatedness (Ryan and Deci, 2000). Gamification elements can address these psychological needs and thus foster intrinsic motivation, which is essential for autonomous and effective learning (Sailer et al., 2017) and is therefore relevant for developing cycling skills.

Empirical studies on the effectiveness of hazard perception training have found large significant effects on skill improvement (Prabhakharan et al., 2024). Research on online cycling trainings has shown that trainings on hazard perception and mitigation can improve safety-relevant cycling skills (Kovácsová et al., 2020; Lehtonen et al., 2017; van Eggermond et al., 2025).

Despite their reported effectiveness in promoting safer cycling behavior, evidence regarding users' evaluation and acceptance of such gamified online training is limited. Assuming that online training has the potential to improve cycling safety, it is essential to understand the factors that influence user acceptance and engagement (Jacobs, 2021) and thus foster continued interaction with safety training contents.

Against this background, the objective of the present study is to better understand the acceptance of an online cycling training. To this end, the study investigates acceptance on a behavioral and attitudinal level and analyses the factors that influence use intentions of an online cycling training. To achieve this, a survey was integrated into a gamified online cycling training to evaluate at both an attitudinal and a behavioral acceptance among participants. This research contributes to the field of transport and health by evaluating a scalable, gamified intervention designed to improve cycling safety among adult urban cyclists. By identifying the motivational factors underlying the adoption of this training, the study offers insights for designing future safety and educational programs within the cycling safety promotion and public health domain.

2. Previous work

The acceptance of an online training can be evaluated at both attitudinal and behavioral levels (Schuitema and Bergstad, 2018). At the attitudinal level, acceptance is measured by specific factors that are hypothesized to influence the intention to use a technology (Venkatesh et al., 2012). At the behavioral level, usage data is analyzed to gain insights into users' actual behavior and their interaction with the technology (Walldén et al., 2016). To lay the foundation for the present study, this section will first introduce the theoretical framework that will serve as the basis to better understand attitudinal dimensions of the acceptance of online cycling trainings: the Unified Theory of Acceptance and Use of Technology (UTAUT2). Subsequently, insights from previous empirical research relevant to the acceptance and usage of online training in general and road safety trainings specifically will be discussed. Finally, we will identify research gaps, leading to the formulation of research questions.

2.1. Theoretical framework for acceptance of online trainings

The Unified Theory of Acceptance and Use of Technology (UTAUT2) (Venkatesh et al., 2012) is a well-established framework used to investigate underlying factors that influence the acceptance of technologies in the educational context (Granić, 2022). An online cycling training is considered a technology because learning is enabled and facilitated through information technology and delivered via smart phones or personal computers (Chao, 2019; Granić, 2022; Venkatesh et al., 2012). UTAUT2 defines seven factors that influence use intention, which in turn influences actual usage (see Fig. 1). Furthermore, the demographic factors of gender and age as well as previous experience with the technology act as moderating factors for use intention.

The seven factors defined by UTAUT2 are the following: *Performance expectancy* refers to the utilitarian value of a technology, which, in the context of an online cycling training, is the perceived improvement in traffic safety. *Effort expectancy* describes the perceived ease of use of an online training. *Social influence* captures the beliefs of one's social environment concerning the technology, specifically, the attitudes of an individual's social group toward online training. *Facilitating conditions* concern the available resources for using a technology, such as the feasibility of integrating an online training into everyday life. *Hedonic motivation* describes the pleasure of using the technology, asking whether using an online training is a fun and pleasurable activity. *Price value* refers to the cost of using the technology, focusing on the financial advantages or disadvantages when using an online training. Finally, *habit* describes the extent to which using an online training has become a habitual behavior.

2.2. Empirical evidence on the acceptance of online road safety trainings

Acceptance of Online Trainings in general. A systematic review by Granić (2022) analyzed studies on digital educational tools, focusing on the applied acceptance model and investigated acceptance factors. Key acceptance factors identified were self-efficacy, subjective norm (related to social influence in UTAUT2), perceived enjoyment (related to hedonic motivation in UTAUT2) and facilitating conditions. Furthermore, factors specifically related to technology were also relevant, such as computer anxiety, system accessibility, and technological complexity.

Hafiza Razami and Ibrahim (2022) have conducted a systematic literature review on the acceptance of digital educational training containing gamification elements. The reviewed studies measured acceptance based on acceptance based on various models, analyzing a variety of acceptance factors. While different models were applied, they contained similar acceptance factors despite differences in terminology. The most relevant factors for the acceptance of digital education training were perceived ease of use (related to effort expectancy in UTAUT2), perceived usefulness (related to performance expectancy in UTAUT2), enjoyment (related to hedonic motivation in UTAUT2), attitude, satisfaction, and social influence.

Focusing on learning on mobile phones, Chao (2019) analyzed general acceptance factors for mobile learning tools, applying UTAUT2, alongside other variables. The intention to use mobile learning was associated with satisfaction, enjoyment (related to hedonic motivation), trust, performance expectancy, and effort expectancy.

The factor price value – operationalized as financial costs – was found to influence the acceptance of e-learning (Twum et al., 2022). Additionally, price value influenced acceptance of a business simulation game (Wang et al., 2020). However, the factor price value was rarely included in investigations of the acceptance of online learning technology since these applications are usually offered without financial costs or benefits (Tamilmani et al., 2018).

A study investigating the acceptance of an online learning platform found that habits influence usage intentions (Ambarwati et al., 2020). Overall, habit was often excluded from investigations on the acceptance of online learning technology due to the lack of experience with online trainings that prevented habitual behaviors.

In conclusion, the most relevant acceptance factors for online educational learning – based on UTAUT2 – are hedonic motivation, performance expectancy, effort expectancy, social influence and facilitating conditions. There is also evidence for the influence of price value and habit on the acceptance,

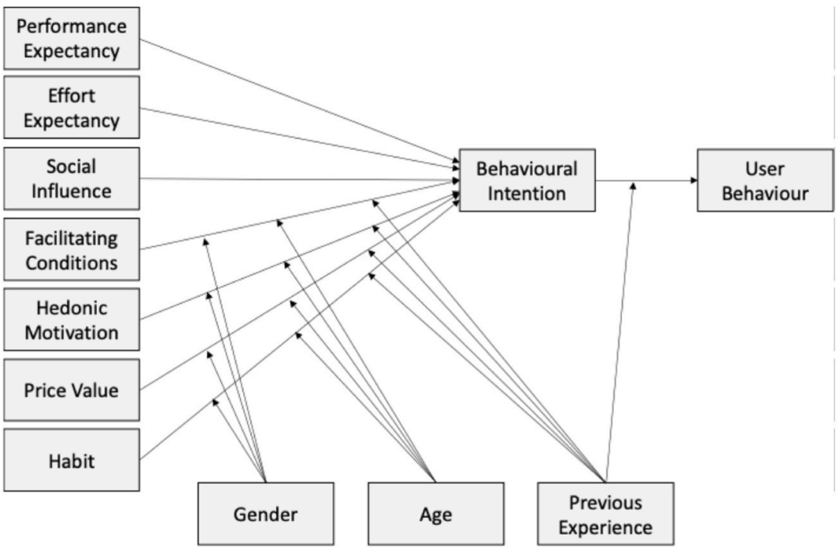

Fig. 1. Model of the Unified theory of acceptance and Use of technology (UTAUT2) (Venkatesh et al., 2012).

Acceptance of Online Trainings in the Context of Road Safety. A review on hazard perception training (Prabhakharan et al., 2024) found five studies training cyclists' hazard perception skills and discussed the effectiveness of these trainings, but not their acceptance.

Specifically focusing on online road safety training, two empirical studies developed and implemented a road safety educational game and partially analyzed its acceptance. Both studies evaluated acceptance without using a theoretical framework. Gounaridou and colleagues (2021) developed a computer game for children and teenagers to train relevant aspects of road safety. In the game, users had to fulfill several missions by reaching specific locations while adhering to traffic rules. The game was evaluated using a small qualitative sample. Results indicated that participants liked learning through games and were satisfied with the content they had learned. Jaunoo and Nagowah (2022) developed a mobile phone game for adults to learn traffic rules in a playful manner. It consisted of different types of quiz questions and a driving simulator game. The game was evaluated using a small qualitative sample. Results showed that participants found learning about traffic safety with a game to be enjoyable and engaging.

Use of Online Trainings in the Context of Road Safety. Empirical research on the use of online, game-based road safety training has shown that this approach can reach a large audience, including the intended target group (Dunwell et al., 2014). Dunwell and colleagues (2014) evaluated a free-to-use serious game about safe pedestrian crossings that was targeted at children designed as a fantasy game. Almost 100,000 children played the game with a median play time of 31 minutes. Boys were the main target audience as they represent a higher-risk group and a quantitative survey of a subsample found that boys were almost four times more likely to participate than girls. A quantitative survey further showed that the game was generally perceived as a fun way of learning and was not considered boring due to its educational content. A qualitative survey indicated that visual communication of content was a promising approach as reading content was sometimes avoided.

Effect of Age and Gender on the Use of Online Trainings. A mixed-method study found no influence of age on online learning interaction participation, perception, or learning satisfaction (Ke and Kwak, 2013). A study about online learning in higher education revealed an effect of gender, finding that females preferred asynchronous teaching compared to males (Tosto et al., 2023).

2.3. Research questions

The literature reveals several research gaps: (1) Few studies have evaluated the *use* or *behavioral acceptance* of an online road safety training. To the best of our knowledge, no empirical study has yet evaluated the usage of an online road safety training aimed at adults or the usage of an online cycling safety training specifically. (2) No study has systematically evaluated the *attitudinal acceptance* of an online road safety training for cyclists. Furthermore, no empirical study has evaluated the acceptance of such a training when aimed at adults. Considering these research gaps, the present study aims to answer the following research questions:

1. Who uses an online cycling training?
   1.1. How does age affect participation in an online cycling training?
   1.2. How does gender affect participation in an online cycling training?
   1.3. How does previous experience (cycling frequency) affect participation in an online cycling training?
2. Which acceptance factors explain the intention to use an online cycling training?
   2.1. How is the online cycling training evaluated on the acceptance factors of the UTAUT2?
   2.2. Which user characteristics (age, gender, and cycling experience) explain the intention to use an online cycling training?
   2.3. Which acceptance factors of the UTAUT2 explain the intention to use an online cycling training?
   2.4. How does cycling frequency influence these relationships?

To answer these research questions, the study surveys participants of a gamified online cycling training that was conducted as part of an online cycling training in an urban setting in Switzerland.

3. Methodology

Procedures: The study developed and implemented an online cycling training program designed to enhance cycling skills among adults. The online cycling training was based on principles of gamification. The following established gamification elements were embedded in the online cycling training: challenge, feedback, scores, monitoring of progress and both tangible and intangible rewards.

The online cycling training consisted of three modules (van Eggermond et al., 2025): two training modules and a final test to assess the acquired skills. Fig. 2 displays the training procedure. Potential participants were invited by letter to partake in the training. Invitations to each module were sent via email at approximately one-week intervals. Participation was incentivized through a raffle.

A prior survey study identified seven relevant cycling skills (Schaffner and van Eggermond, 2021). These skills included: navigating curved priority roads, Y-junctions, determining priority at unsignalized intersections, roundabouts without cycling facilities, cycling along on-street parking, different variants of left turns, and blind spots near large vehicles. Each situation requires specific cognitive and motor skills, such as shoulder-checking or signaling and adjusting speed. To train these skills in the online training, 24 different tasks were created. For each cycling skill, a series of photos, videos, and sketches was developed to support questions and provide feedback. This feedback consisted of positive confirmation for correct answers, mainly in the form of affirming visualizations, and

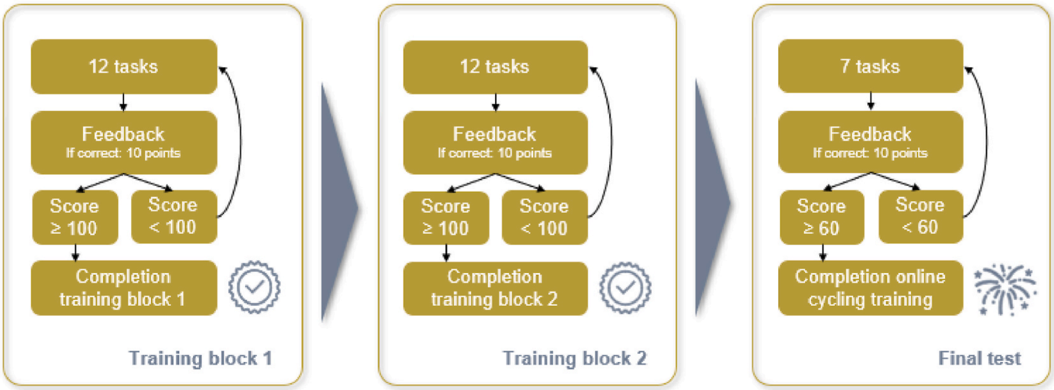

Fig. 2. Procedure for participating in online cycling training.

explanations for incorrect ones. The training was developed in an iterative process with content, structure, and design repeatedly tested through user tests. The training was implemented using the survey software Qualtrics. An example of the cycling training can be seen in Fig. 3.

Each training module consisted of 12 tasks. Correct answers were awarded 10 points, partially correct answers were given 5 points. A score of 100 points was required to complete a training module. The final test consisted of seven tasks drawn from previously learned material, requiring a score of at least 60 points for successful completion. These techniques—scoring, progress tracking, and incentives—were incorporated to promote engagement and support the learning process.

The online bicycle training has been found to effectively improve cycling safety at both a subjective and a behavioral level (van Eggermond et al., 2025).

The study was conducted in accordance with the ethical guidelines of the School of Applied Psychology. All participants were informed about the nature and purpose of the study and provided informed consent prior to participation.

Questionnaire: Acceptance of the online cycling training was measured using a short version of the questionnaire for UTAUT2 (Venkatesh et al., 2012). All factors of UTAUT2 were measured except for social influence as only a select sample participated and the training was not launched for the wider public, and habit as none such could be established due to the novelty of the training.

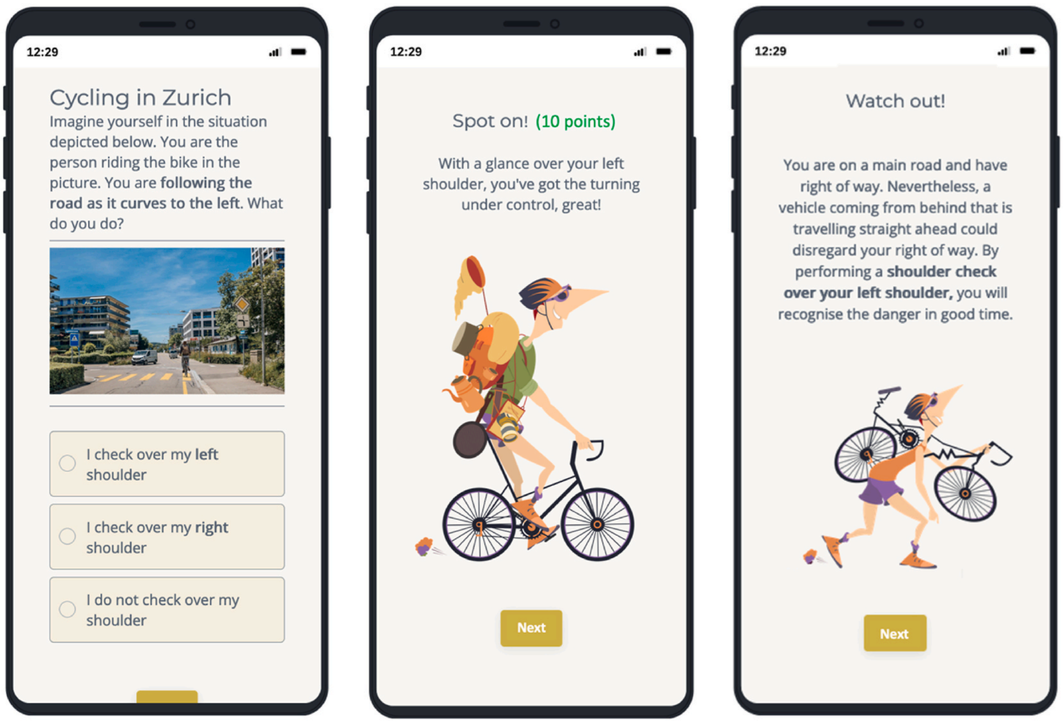

Fig. 3. Example item from the cycling training, showing a question with feedback for correct and incorrect answers.

Measures: To analyze usage of the online cycling training, we assessed the characteristics of three groups: invited participants, participants who only completed the first module, and participants who completed the entire training. Participants indicated their age, gender, and cycling frequency. To analyze how participants accepted the online cycling training, acceptance factors were measured after completing the first module and after completing the final test. Effort expectancy, facilitating conditions and price value were measured with a single item. Performance expectancy was measured with two items: perceived improvement in traffic safety and perceived learning effect. Hedonic motivation was also measured with two items: fun and design of the training. In the first measurement, behavioral intention was measured with the intention to continue the training. In the second measurement, behavioral intention was measured with the two items: The intention to participate again and the likeliness to recommend the training to others. All answers were collected on a 5-point Likert scale, ranging from (1) *Not at all* to (5) *Very much*.

Statistical analysis: To analyze differences in participation, user characteristics were compared at the different stages of participation (from invitation to completion of the entire training) using a Pearson's Chi-squared test. For the acceptance items, which were measured on 5-point Likert scales, we examined the distributions and found evidence of skewness, particularly negative skew due to ceiling effects. Since individual Likert items are ordinal in nature and often deviate from normality, we used Mann–Whitney U tests to compare responses between participants who completed only the first module and those who completed all three modules. Effect sizes were calculated as rank-biserial correlations. This indicator provides an interpretable measure of association suitable for ordinal outcomes. This choice is in line with methodological recommendations for Likert-type data (de Winter and Dodou, 2010). Finally, an ordinal logistic regression analysis was conducted to evaluate which user characteristics and acceptance factors explained use intention. This approach is recommended for modeling Likert-type outcomes, as it accounts for their ordinal nature without assuming equal spacing between categories (e.g. McCullagh, 1980). Analyses were performed in R (R Core Team, 2023) using the `clm` function from the *ordinal* package (Christensen, 2010).

4. Results

4.1. Demographics of users

The number of participants over the three modules of the online training and their sociodemographic data are shown in Table 1. A total of 9670 citizens between the age of 18 and 59 were randomly selected from the city registry of Zurich (Switzerland) and invited via mail to participate in the online training program. The number of invitations for each age group was balanced based on the proportion of cyclists in this age group and the expected response rate. Therefore, relative to age group and previous experience, young people were oversampled relative to their representation in the population.

75 participants were excluded from the sample that completed module 1 because they did not meet the requirements. This resulted in 1182 participants that completed module 1, yielding a response rate of 12 %. 822 participants completed module 2. Due to a technical error, 15 participants skipped module 2 and were thus excluded from the final sample. Ultimately, 708 participants that completed all three modules, resulting in a final response rate of 7.3 %. The completion rate across all three modules was 60 %.

Participants of the final sample consisted of 53 % men, 46 % women, and 1 % of diverse gender. The proportion of gender in the

Table 1
Sociodemographic data of the participants in the online cycling training.

	Invited participants (n = 9670)		Completed module 1 (n = 1182)		Completed module 2 (n = 822)		Completed whole training (n = 708)		Participants that only completed module 1 (n = 345)	
	n	%	n	%	n	%	n	%	n	%
Gender										
Female	4691	49 %	532	45 %	392	48 %	325	46 %	135	39 %
Male	4979	51 %	577	49 %	417	51 %	374	53 %	150	43 %
Diverse			21	1.8 %	12	1.5 %	8	1.1 %	9	2.6 %
Not available			52	4.4 %	1	0.1 %	1	0.1 %	51	15 %
Age group										
18–29	3594	37 %	340	29 %	252	31 %	212	30 %	84	24 %
30–39	3291	34 %	439	37 %	312	38 %	276	39 %	119	34 %
40–49	1926	20 %	259	22 %	188	23 %	160	23 %	68	20 %
50–59	859	9 %	75	6 %	59	7 %	51	7 %	16	4.6 %
Not available			69	6 %	11	1.3 %	9	1.3 %	58	17 %
			n	%	n	%	n	%	n	%
Cycling frequency										
Multiple days per week			815	69 %	588	72 %	510	72 %	216	63 %
Multiple days per month			237	20 %	161	20 %	140	20 %	74	21 %
Once a month or less			130	11 %	73	9 %	58	8 %	55	16 %
Number of cycling purposes										
1			222	19 %	135	16 %	118	17 %	82	25 %
2			302	26 %	205	25 %	175	25 %	94	27 %
3			349	30 %	252	31 %	214	30 %	95	28 %
4			309	26 %	230	28 %	201	28 %	74	21 %

final sample significantly differed from the invitations (X2 (2) = 126.7, p < .001) and from participants that completed module 1 (X2 (2) = 6.3, p = .04). This indicates that more men than women completed the online training. Mean age was 35.5 years, the median age was 34 years. Compared to the invitations, fewer people from the age group of 18–29 and more people from the age group 30–39 and 50–59 participated in module 1 (X2 (3) = 292.6, p < .001). However, age distribution did not differ between participants that completed module 1 and participants that completed the whole training (X2 (3) = 0.6, p = .90).

4.2. Cycling behavior of users

Cycling frequency. Table 1 also shows the cycling frequency and number of cycling purposes of the participants across the three modules of the online training. In the final sample that completed the entire training, 72 % of the participants cycled multiple times per week, 20 % cycled multiple times per month, and 8 % cycled once a month or less. In the sample that only completed module 1, 63 % cycled multiple days per week, 21 % cycled multiple days per month, and 16 % cycled once a month or less. A Pearson's Chi-squared test showed a significant difference in cycling frequency between the two groups (X2 (2) = 30.0, p < .001).

Cycling purpose. Regarding the number of cycling purposes (work/education, shopping, leisure, sport), 58 % of the participants that completed the entire training, used their bicycle for three or more purposes, compared to 49 % of participants who only completed Module 1. Participants who completed the whole training had a significantly higher average number of cycling purposes (M = 2.70, SD = 1.05) than participants that only completed module 1 (M = 2.47, SD = 1.08, t(670) = 3.37, p < .001).

4.3. Acceptance: descriptive statistics

Table 2 presents mean, median, and interquartile range (IQR) values for acceptance factors, comparing participants who only completed module 1 (n = 319) with those who completed all three modules (n = 693). The table also shows Mann–Whitney U test statistics (U) and effect sizes (r) for group comparisons. The strongest differences were observed for behavioral intention to continue. This suggest that participants who completed the training were more motivated by the prize incentive and more likely to express intentions to continue. Smaller but still significant differences were found for effort expectancy (ease of use): participants who continued with the training also perceived the training as more convenient to use.

Ratings for hedonic motivation (fun) and facilitating conditions were slightly higher among completers, but with only small effect sizes (r < 0.10). No significant differences emerged for performance expectancy (safety and learning), where both groups reported similar perceptions of training benefits.

Table 3 presents the acceptance ratings of participants who completed the entire training, stratified by their cycling frequency, after completing module 1. Low cycling frequency is defined as cycling "multiple days per month" or "once a month or less", while high cycling frequency is defined as cycling "multiple days per week". Significant differences were found for performance expectancy and hedonic motivation. Low-frequency cyclists more strongly agreed that the training helped them ride more safely and that they learned something from the training. They also reported that the training was more fun to use. These results suggest that infrequent cyclists perceive greater added value from the training in terms of safety, learning, and enjoyment.

No significant group differences were observed for effort expectancy (ease of use), facilitating conditions, design, or price value (prizes). Both groups rated the training as very easy to use, indicated that the design was appealing and the relevance prize incentives.

Finally, behavioral intention to continue the training was high in both groups, with no significant difference between low- and high-frequency cyclists.

Table 2
Acceptance of an online cycling training by participants who only completed module 1 and participants who completed the entire training. Acceptance ratings ranged from 1 (strongly disagree) to 5 (strongly agree). Values are reported as means, medians, and interquartile ranges (IQR), with Mann–Whitney U test statistics (U) and effect sizes (r).

Acceptance factor	Item	Only completed module 1 (n = 319)			Completed module 3 (n = 693)				
		Mean	Median	IQR	Mean	Median	IQR	u	r
Performance expectancy	I ride more safely thanks to the online cycling training.	3.51	4	1	3.62	4	1	105827.5	0.04
	I have learned something by using the online cycling training.	3.92	4	2	4.02	4	1	106398	0.03
Effort expectancy	The online cycling training is easy to use.	4.47	5	1	4.63	5	1	96533 ***	0.12
Facilitating conditions	The online cycling training can be used in everyday life.	3.92	4	2	4.10	4	1	101307.5	0.07
Hedonic motivation	The online cycling training is fun.	3.73	4	1	3.92	4	2	100380	0.08
	The online cycling training has an attractive design.	4.01	4	1	4.18	4	1	98370 *	0.10
Price value	I can win attractive prizes (raffle) with the online cycling training.	3.85	4	2	4.16	4	1	90891 ****	0.15
Behavioural intention	I will continue with the online cycling training.	4.10	4	1	4.49	5	1	87715 ****	0.18

*p < .05, **p < .01, ***p < .001.

Table 3
Acceptance of an online cycling training by participants that completed the entire training, depending on their cycling frequency. Acceptance ratings ranged from 1(strongly disagree) to 5 (strongly agree). Values are reported as means, medians, and interquartile ranges (IQR), with Mann–Whitney *U* test statistics (*U*) and effect sizes (*r*).

Acceptance factor	Item	Low cycling frequency (n = 196)			High cycling frequency (n = 497)				
		Mean	Median	IQR	Mean	Median	IQR	u	r
Performance expectancy	I ride more safely thanks to the online cycling training.	3.87	4	1	3.52	4	1	38682.5 ****	0.17
	I have learned something by using the online cycling training.	4.23	4	1	3.93	4	2	41053 **	0.13
Effort expectancy	The online cycling training is easy to use.	4.68	5	1	4.62	5	1	47323.5	0.03
Facilitating conditions	The online cycling training can be used in everyday life.	4.22	4	1	4.05	4	1	43903	0.08
Hedonic motivation	The online cycling training is fun.	4.10	4	1	3.85	4	1	41585 *	0.12
	The online cycling training has an attractive design.	4.22	4	1	4.16	4	1	46761.5	0.03
Price value	I can win attractive prizes (raffle) with the online cycling training.	4.22	4	1	4.13	4	1	45322	0.06
Behavioural intention	I will continue with the online cycling training.	4.53	5	1	4.47	5	1	46081.5	0.05

*p < .05, **p < .01, ***p < .001.

4.4. Acceptance: regression models

4.4.1. Intention to continue the cycling training (module 1)

Table 4 presents the results of three hierarchical ordinal logistic regression models predicting the intention to continue the cycling training after module 1. The sample used for this analysis includes only participants who completed the entire cycling training. Each model adds a block of predictors. This allows for the assessment of the incremental contribution of new variables and the robustness of earlier effects.

In Model 1, which only contained sociodemographic variables, gender was significant: women were about 40 % more likely than men to express intentions to continue (OR = 1.40, p < .05). Neither age nor cycling frequency were significant predictors. Overall model fit was poor (McFadden's $\rho^2 = 0.006$), indicating that demographics alone explain little variation in the intention to continue the training.

Model 2, which added acceptance factors, substantially improved model fit ($\rho^2 = 0.184$). Several predictors became significant. For each one-unit increase in perceived learning benefits, the odds of intending to continue rose by 53 % (OR = 1.53, p < .001). Participants who perceived the training as fun were more than twice as likely to continue (OR = 2.20, p < .001). Similarly, valuing prizes increased the odds of continuation by 72 % (OR = 1.72, p < .001). Ease of use (OR = 1.27) and facilitating conditions (OR = 1.22) were statistically significant at the 10 % level, suggesting that participants who perceived the training as easier to use or more applicable in everyday life were about 27 % and 22 % more likely, respectively, to intend to continue. The gender effect observed in Model 1 was no longer significant once acceptance factors were included, suggesting that gender differences were largely explained by variation in acceptance perceptions.

In the final model, the main effect of cycling frequency was strongly associated with the intention to continue the training (OR = 173.42, p < .05), meaning high-frequency cyclists were far more likely to continue. This large odds ratio reflects the fact that nearly all high-frequency cyclists reported strong intentions to continue; thus, the estimate should be interpreted as indicating a strong positive association with the intention to continue.

Acceptance factors remained consistent: fun increased the odds by a factor of 3.5 (OR = 3.53, p < .001), while valuing prizes more than doubled the odds (OR = 2.25, p < .001). The interaction between cycling frequency and fun was significant and negative (OR = 0.56, p < .05), indicating that the positive effect of fun was weaker among frequent cyclists. For frequent cyclists, each one-unit increase in perceived improvement in safe riding was associated with a 7 % decrease in the odds of intending to continue (OR = 0.93, p < .10). Also, for frequent cyclists, each one-unit increase in ease of use was associated with a 28 % decrease in the odds of intending to continue (OR = 0.72, p < .10). No other interactions were significant. Model fit modestly improved over Model 2 ($\rho^2 = 0.194$).

4.4.2. Intention to participate anew (final test)

Table 5 shows the results of the ordinal logistic regression models predicting the intention to participate anew in an online cycling training, assessed after completion of the training. The model has fewer observations (four) as one acceptance question was not mandatory.

In Model 1, only including sociodemographic variables, age was not a significant predictor of re-participation. Gender showed a small effect, with women being 36 % more likely than men to intend to participate again (OR = 1.36, p < .05). Cycling frequency was negatively associated with the intention to participate a new (OR = 0.58, p < .01), indicating that frequent cyclists were about 42 % less likely to intend to participate again than infrequent cyclists. Overall, the explanatory power of this model was very limited (McFadden's $\rho^2 = 0.04$).

Adding acceptance factors in Model 2 greatly improved model fit (McFadden's $\rho^2 = 0.28$). In this model, demographic effects were no longer significant whereas several acceptance variables were significant. Perceiving the training as fun was the strongest predictor

Table 4
Ordinal logistic regression of the intention to continue the cycling training after module 1 (n = 693).

Block 1: Demographics	Est. (Std. Err)	OR (CI)	Est. (Std. Err)	OR (CI)	Est. (Std. Err)	OR (CI)
Age	−0.009 (0.01)	0.991 (0.97,1.01)	−0.008 (0.01)	0.992 (0.97,1.01)	−0.009 (0.01)	0.991 (0.97,1.01)
Gender (0 = male, 1 = female)	0.338 (0.15)*	1.402 (1.04,1.89)	0.139 (0.17)	1.149 (0.82,1.6)	0.121 (0.17)	1.129 (0.81,1.58)
Cycling frequency (0 = Low frequency, 1 = High frequency)	−0.202 (0.17)	0.817 (0.58,1.14)	0.151 (0.19)	1.163 (0.8,1.69)	5.156 (2.01)*	173.42 (3.54,9343.97)
Block 2: Acceptance factors						
Performance Expectancy: Safety			−0.032 (0.13)	0.969 (0.75,1.24)	0.038 (0.27)	1.038 (0.61,1.78)
Performance Expectancy: Learning			0.424 (0.12)***	1.529 (1.21,1.94)	0.085 (0.27)	1.089 (0.64,1.83)
Effort expectancy: Ease of use			0.241 (0.15)$^+$	1.272 (0.96,1.7)	0.532 (0.34)	1.703 (0.87,3.3)
Facilitating conditions: Use in everyday life			0.199 (0.12)$^+$	1.22 (0.97,1.53)	0.376 (0.26)	1.456 (0.88,2.43)
Hedonic motivation: Fun			0.788 (0.12)***	2.2 (1.74,2.79)	1.26 (0.26)***	3.525 (2.15,5.9)
Hedonic motivation: Design			0.153 (0.12)	1.165 (0.92,1.47)	0.198 (0.25)	1.219 (0.75,1.98)
Price value: Prizes			0.542 (0.1)***	1.719 (1.41,2.1)	0.809 (0.2)***	2.245 (1.51,3.37)
Block 3: Interaction effect with cycling frequency (CF)						
CF * Performance Expectancy: Safety					−0.072 (0.31) +	0.931 (0.51,1.71)
CF * Performance Expectancy: Learning					0.421 (0.3)	1.524 (0.85,2.76)
CF * Effort expectancy: Ease of use					−0.331 (0.37) +	0.718 (0.35,1.5)
CF * Facilitating condition: Use in everyday life					−0.241 (0.29)	0.786 (0.44,1.38)
CF * Hedonic motivation: Fun					−0.574 (0.29)*	0.563 (0.32,0.98)
CF * Hedonic motivation: Design					−0.075 (0.28)	0.928 (0.53,1.61)
CF * Price value: Prizes					−0.347 (0.23)	0.707 (0.44,1.11)
Thresholds						
1|2	−6.881 (1.05)***		1.979 (1.33)		5.929 (2.11)**	
2|3	−4.791 (0.48)***		4.076 (0.95)***		8.049 (1.9)***	
3|4	−3.186 (0.37)***		5.756 (0.91)***		9.738 (1.89)***	
4|5	−0.545 (0.34)		9.085 (0.96)***		13.096 (1.93)***	
Goodness-of-fit indicators						
McFadden's Rho Square	0.01		0.18		0.19	
AIC	1233.77		1029.60		1030.88	
BIC	1265.55		1093.18		1126.24	

$^+$ p < .1, *p < .05, **p < .01, ***p < .001.

to participate anew: participants who found the training fun were more than three times as likely to intend to participate anew (OR = 3.37, p < .001). Price value in terms of prizes was also influential, with participants who valued the prizes being more than twice as likely to re-participate (OR = 2.37, p < .001). Perceived learning increased the odds of participating anew by 44 % (OR = 1.44, p < .01). Other acceptance factors, including perceived safety, ease of use, facilitating conditions, and design, did not significantly predict the intention to participate anew in this model.

Including interaction terms in Model 3 improved model fit further (McFadden's $\rho^2 = 0.29$). The main effects of fun (OR = 4.66, $p <$ .001), prizes (OR = 2.45, $p < .001$), and learning (OR = 1.89, $p < .05$) remained strong. In this model, design also became significant: participants who rated the design positively were about twice as likely to participate anew (OR = 2.01, $p < .01$). The interaction between cycling frequency and design was negative (OR = 0.39, $p < .01$), indicating that the positive effect of design on the intention to participate anew was driven mainly by infrequent cyclists, while design mattered less for frequent cyclists. Other interaction effects were not significant.

5. Discussion

The aim of this study was to assess the acceptance of an online cycling training program designed to promote safe cycling among adult cyclists. Acceptance was analyzed over the course of the online cycling training, with a survey integrated into the training as part

Table 5
Ordinal logistic regression of the intention to participate anew, assessed after module 3 (n = 689).

Block 1: Demographics	Model 1		Model 2		Interaction model	
	Est. (Std. Err)	OR (CI)	Est. (Std. Err)	OR (CI)	Est. (Std. Err)	OR (CI)
Age	0.009 (0.01)	1.009 (0.99,1.03)	0.008 (0.01)	1.008 (0.99,1.03)	0.004 (0.01)	1.004 (0.98,1.02)
Gender (0 = male, 1 = female)	0.309 (0.15)*	1.362 (1.02,1.83)	−0.111 (0.17)	0.895 (0.64,1.26)	−0.151 (0.18)	0.86 (0.61,1.21)
Cycling frequency (0 = Low frequency, 1 = High frequency)	−0.548 (0.17)**	0.578 (0.41,0.8)	−0.205 (0.2)	0.815 (0.55,1.2)	0.405 (2.36)	1.5 (0.01,159.25)
Block 2: Acceptance factors						
Performance Expectancy: Safety			0.105 (0.14)	1.111 (0.84,1.46)	−0.389 (0.31)	0.678 (0.37,1.23)
Performance Expectancy: Learning			0.362 (0.13)**	1.436 (1.11,1.86)	0.638 (0.29)*	1.893 (1.08,3.36)
Effort expectancy: Ease of use			0.109 (0.19)	1.116 (0.77,1.62)	−0.54 (0.46)	0.582 (0.23,1.42)
Facilitating conditions: Use in everyday life			0.09 (0.13)	1.094 (0.85,1.4)	0.157 (0.32)	1.17 (0.62,2.18)
Hedonic motivation: Fun			1.214 (0.15)***	3.366 (2.53,4.52)	1.539 (0.3)***	4.658 (2.6,8.54)
Hedonic motivation: Design			−0.022 (0.13)	0.978 (0.76,1.25)	0.696 (0.27)**	2.006 (1.18,3.41)
Price value: Prizes			0.864 (0.11)***	2.372 (1.92,2.95)	0.895 (0.24)***	2.447 (1.54,3.93)
Block 3: Interaction effect with cycling frequency (CF)						
CF * Performance Expectancy: Safety					0.649 (0.35)	1.914 (0.98,3.83)
CF * Performance Expectancy: Learning					−0.324 (0.32)	0.723 (0.38,1.36)
CF * Effort expectancy: Ease of use					0.908 (0.51)	2.48 (0.92,6.84)
CF * Facilitating condition: Use in everyday life					−0.107 (0.35)	0.899 (0.46,1.78)
CF * Hedonic motivation: Fun					−0.394 (0.34)	0.674 (0.34,1.3)
CF * Hedonic motivation: Design					−0.947 (0.31)**	0.388 (0.21,0.71)
CF * Price value: Prizes					−0.007 (0.27)	0.994 (0.59,1.67)
Thresholds						
1|2	−5.808 (0.78)***		3.429 (1.19)**		4.103 (2.38)	
2|3	−3.843 (0.42)***		5.913 (1)***		6.636 (2.25)**	
3|4	−2.032 (0.34)***		8.325 (1)***		9.045 (2.24)***	
4|5	−0.055 (0.33)		11.247 (1.05)***		12.021 (2.26)***	
Goodness-of-fit indicators						
McFadden's Rho Square	0.038		0.280		0.293	
AIC	1389.45		1057.32		1052.03	
BIC	1421.19		1120.81		1147.27	

$^{+}$ p < .1, *p < .05, **p < .01, ***p < .001.

of a pilot study implementing an online cycling training. Participants were invited via postal mail and participated in three modules, completed on a weekly basis. Acceptance was measured after the first module and upon completion of the final module, using the Unified Theory of Acceptance and Use of Technology (UTAUT2) framework (Venkatesh et al., 2012). The evaluation was conducted by analyzing participants' intentions to continue with the training and to participate again.

5.1. Contribution to the literature and to practice

This section discusses the findings of the present study along the research questions.

Who uses an online cycling training (Research Question 1). The study shows that a considerable share of urban cyclists is willing to complete an online cycling training to improve the mastering of complex traffic situations. Once participants started with the training, a relatively high completion rate was observed across the three training modules. Psychologically, this might be explained by the fact that people feel uneasy with uncompleted tasks, consistent with the Zeigarnik Effect (Festinger, 1962; Zeigarnik, 1938).

Answering *Research Question 1.1*, the present study finds that younger people were less likely to participate compared to middle-aged or older participants, indicating that age influences participation in an online training.

In response to *Research Question 1.2,* the present study finds that more men than women completed the training, suggesting an influence of gender on participation. While gender was initially a significant predictor in the regression models (with women being more likely to continue), the explained variance was small, and the effect of gender disappeared once acceptance factors were included. Once acceptance factors were included, however, the effect of gender disappeared. Overall, this indicates that cycling frequency plays a more important role than other sociodemographic factors such as age and gender in explaining acceptance.

In answer to *Research Question 1.3,* the cycling training predominantly attracts participants who already cycle frequently. This finding is in line with previous studies showing that gamified interventions often attract an audience already engaged in the targeted behavior (Tsirimpa et al., 2019). On the one hand, this is a positive outcome since these individuals may benefit more from improving their cycling skills as they have more opportunities to apply them (e.g. they are exposed to more risk in terms of travel time and travel distance). On the other hand, the limited engagement of infrequent cyclists signals a potential gap in reaching a secondary target audience. This is relevant because infrequent cyclists could benefit from such a training by improving their safety awareness in less familiar traffic situations. Doing so could build greater cycling confidence and potentially increase their motivation to use cycling as a mode of transportation.

Research Question 2.1 addresses the question, how the online cycling training is evaluated on the acceptance factors of the UTAUT2. In general, the online cycling training received above-average acceptance ratings across all factors – even from participants that discontinued the training after module 1. This finding confirms previous results of high satisfaction with online trainings, extending them from children to adult cyclists (Gounaridou et al., 2021). Participants who completed the training rated effort expectancy (ease of use), hedonic motivation (fun and design), and price value (attractive prizes) highly, indicating that these were considered as important aspects of the experience. The lowest acceptance ratings pertained to the effect of the training on performance expectancy (safety and learning outcomes). This highlights a misalignment between user perceptions and the intended training goals: to enhance safety awareness and impart useful safety knowledge.

Discrepancies often exist between the perception of learning and actual learning outcomes; it is possible that one learns more despite not having a strong awareness of learning (Deslauriers et al., 2019). Indeed, the effectiveness of this specific online cycling training was confirmed in an experimental study, where cycling skills improved on both a self-report measure and a behavioral measure within a virtual reality cycling simulator (van Eggermond et al., 2025). However, according to the self-determination theory, the subjective feeling of learning is important for maintaining a sense of competence and fostering motivation (Ryan and Deci, 2000). Furthermore, the perception of learning might help to gain cycling confidence. Hence, it is recommended that the online cycling training be re-evaluated to determine how the awareness of learning outcomes can be improved and the learning progress made more tangible.

The influence of age, gender and cycling frequency on acceptance was examined based on regression models, answering *Research Question 2.2*. The results show that cycling frequency plays a significant role in the acceptance of an online cycling training, whereas other sociodemographic factors, such as age and gender, were not relevant when including acceptance factors in the model. Frequent cyclists are more likely to accept an online cycling training compared to infrequent cyclists. This partially confirms the UTAUT2 framework (Venkatesh et al., 2012), as habit - operationalized as cycling frequency - explains the usage intentions of the online training. Furthermore, the study confirms previous investigations in the more general context of online learning that gender and age do not appear to influence usage intentions (Ambarwati et al., 2020; Ke and Kwak, 2013; Wang et al., 2020).

To answer *Research Question 2.3* the influence of acceptance factors based on UTAUT2 on usage intention was analyzed. Perceiving the training as fun emerged as the most relevant factor to continue participation and the intention to participate again. By identifying fun as an important factor, the present study confirms findings from previous research on online trainings in general (Chao, 2019; Granić, 2022; Hafiza Razami and Ibrahim, 2022) for the context of cycling safety trainings. This suggests that hedonic motivations and positive emotions evoked by the training positively influence acceptance. Our study additionally confirms that fun is important for explaining usage intentions of an online road safety training for children and adults alike (Dunwell et al., 2014; Jaunoo and Nagowah, 2022). Hence, designers of online cycling safety trainings are recommended to incorporate gamification elements that ensure an enjoyable learning journey.

Furthermore, attractive prizes were an important factor to ensure acceptance of the online cycling training, especially for the intention to participate again. This finding is generally in line with the theoretical UTAUT2 framework (Granić, 2022a; Venkatesh et al., 2012), providing evidence for the influence of price value on usage intentions. This result is also in line with findings on the acceptance of online trainings in general (Tamilmani et al., 2018; Twum et al., 2022) and adds to the existing knowledge on the acceptance of online trainings in the road safety context by identifying the importance of extrinsic rewards on usage intentions.

The present study also contributes to existing research by further refining the construct of performance expectancy for online trainings in the context of road safety, operationalized here as learning and improving traffic safety. Generally, the results show that the perceived learning is of importance in explaining use intention.

However, perceived improvements in traffic safety alone did not predict use intention of the cycling training. This missing effect might be explained by cognitive biases that affect subjective skill assessments (Sundström, 2008). Participants may have overestimated their existing safety skills, leading them to underestimate the benefits of the online training. Hence, the overall results concerning performance expectancy – operationalized here as learning and improvements in traffic safety – partially align with previous findings which highlight its relevance for the intention to use online trainings (Chao, 2019; Hafiza Razami and Ibrahim, 2022).

Taken together, these findings highlight the importance of addressing both intrinsic (e.g. fun, learning) and extrinsic (e.g. prizes, rewards, motivational drivers). This aligns with principles of the self-determination theory (Ryan and Deci, 2000), which emphasizes that long-term engagement is reinforced when intrinsic enjoyment and competence are combined; extrinsic rewards can provide additional incentives.

Effort expectancy (ease of use) and facilitating conditions were relevant factors in the decision to continue the training, contributing to intentions to proceed after module 1. However, these factors did not significantly influence the intention to participate again once the training was completed This is likely because users had become familiar with the training and had learned to integrate the training into their daily routines. This finding refines previous insights, suggesting that ease of use generally influences acceptance of road safety trainings (Hafiza Razami and Ibrahim, 2022), indicating that this influence is primarily limited to the initial stage of adoption.

To answer *Research Question 2.4* interaction effects with cycling frequency were analyzed. The results show that hedonic motivation (fun) was more relevant for infrequent cyclists to continue the training. Infrequent cyclists may be more drawn to engaging and rewarding experiences instead of acquiring cycling skills they are only occasionally able to apply – notwithstanding the importance of those skills for them.

Interestingly, while perceived improvements in traffic safety alone did not predict use intention, the interaction with cycling frequency revealed an effect: safety was less important for frequent cyclists. This is likely because this group already felt sufficiently safe. Moreover, the design of the online training was a significant predictor of the intention to participate again, with a stronger effect among participants with low cycling frequency. This underlines the importance of an attractive design for engaging infrequent cyclists, whereas design still played a positive, though less pronounced, role for frequent cyclists.

To the best of our knowledge, this is the first study to assess acceptance and use of an online training for cycling safety among adults. It extends on previous research on acceptance of online road safety trainings (Gounaridou et al., 2021; Jaunoo and Nagowah, 2022) by applying a comprehensive theoretical framework (UTAUT2) to study different acceptance factors. The present study also contributes to research on the use of online, game-based trainings (Dunwell et al., 2014) by specifically investigating its application in the context of cycling safety. It extends the understanding of how engaging, interactive training programs can be designed to improve safety awareness among adult cyclists and provides insights for both research and practical interventions in the field of road safety.

Combined, these findings suggest that an online cycling training is accepted by cyclists and may therefore present a promising tool to promote engagement in cycling, an activity widely recognized as health-promoting.

5.2. Limitations

Several limitations must be considered when interpreting the findings. Direct comparisons between training participation and broader population statistics are not feasible due to the use different indicators used for measuring cycling usage. Consequently, the extent to which the sample accurately represents the broader cycling population remains uncertain. Furthermore, the training invitations were distributed exclusively within an urban sample. This limits the generalizability of the findings to the entire population of cyclists, including cyclists from rural areas, where different cycling infrastructure and different cycling cultures may prevail.

The specific reasons why some participants did not continue with the training remain largely unknown and might also include external factors such as technical issues (e.g., failure to receive email reminders). While we examined the differences between participants who only completed module 1 and participants that completed the entire training, the former probably do not accurately represent individuals who did not enroll in the training at all. Given the absence of data from non-participants, it remains unclear what factors contributed to their decision. This limitation precludes conclusions about the non-participating population and highlights the need for further research incorporating strategies to assess non-participation systematically when evaluating general acceptance of an online cycling training.

6. Conclusion

This study examined who participates in online cycling training and which factors drive acceptance and intentions to continue.

Because uptake depends on acceptance, understanding these factors is an important step toward developing effective online cycling interventions. In response to Research Question 1 (Who uses an online cycling training?), findings indicate that frequent cyclists are more likely to participate. Future training interventions should be designed to engage infrequent cyclists as an additional relevant target group for building confidence and expanding overall cycling mode share. In response to Research Question 2 (What factors explain usage intentions?), the study finds that both intrinsic motivations (e.g., fun and perceived learning success) and extrinsic motivations (e.g., attractive prizes) strongly drive the intention to continue with such a training as well as to participate anew. Future research should investigate strategies to further enhance the learning experience and assess the long-term effects of online training in real-world contexts.

Overall, the results suggest that gamified online training is a scalable and accessible tool for enhancing cycling safety, with potential applications in broader public health and road safety initiatives.

CRediT authorship contribution statement

Nora Studer: Writing – review & editing, Writing – original draft, Project administration, Investigation, Formal analysis, Data curation, Conceptualization. **Michael A. B. van Eggermond:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Dorothea Schaffner:** Writing – review & editing, Writing – original draft, Supervision, Investigation, Funding acquisition, Conceptualization. **Lucy Johnson:** Writing – review & editing, Project administration, Investigation. **Leah Knecht:** Investigation, Formal analysis.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dorothea Schaffner reports financial support was provided by AXA Foundation for Accident Prevention. Dorothea Schaffner reports financial support and administrative support were provided by City of Zurich. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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