

Interactive Education to Improve Traffic Safety Awareness at SMAN 1 Harau Through Card Games

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ABSTRACT

Traffic safety remains a significant issue among adolescents in Indonesia. Senior high school students represent a particularly susceptible demographic. This community service initiative aimed to enhance students' understanding of road safety at SMAN 1 Harau via an interactive card game called Road Smart Card. The program was executed with a one-group pretest-posttest design involving 30 students. The Traffic Smart Card featured depictions of traffic signs, authentic traffic scenarios, and educational inquiries to promote dialogue and contemplation. The results indicated a notable enhancement in students' knowledge, with a posttest mean score of 90.50 compared to a pretest mean score of 71.17, reflecting a 27.17% gain. The mean N-Gain score is 0.68, categorizing it as high and affirming the efficacy of the learning medium. Fifty percent of students achieved a high gain classification, while the remaining fifty percent fell into a medium group, with no students categorized as low. Over 90% of the students actively participated in group discussions and game activities, fostering an engaging and enjoyable learning environment. The therapy also resulted in emotional and behavioral changes in addition to cognitive improvements. The school committed to including media in standard educational practices, the School Safety Patrol extracurricular program, and OSIS activities. The program effectively enhanced understanding and road safety culture among young students in a pertinent and sustainable manner.

Keywords: Card Game; Gamification; Interactive Education; N-Gain; Traffic Safety.

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INTRODUCTION

Traffic safety among adolescents is a critical problem in Indonesia. The National Traffic Police (Korlantas Polri) recorded 11,565 traffic accident cases in January 2024, with 32.4% or 4,464 of them involving riders aged 17 to 29 years [1]. This figure was higher compared to the same period the previous year, when 4,293 of 12,000 cases (31.8%) involved adolescents. The Ministry of Transportation's data in 2020 also showed that the largest number of traffic accident victims were students of senior high school (SLTA), as many as 80,641 people [2]. The main causes of the high accident rate include poor knowledge of traffic rules, low safety awareness among adolescents, and the fact that many young people begin riding motorcycles before they are legally or mentally prepared to handle the risks of the road.

Local communities reflect and, in some cases, intensify these national patterns. SMA Negeri 1 Harau is located at Jalan Raya Negara KM 7, Koto Tuo, Kecamatan Harau, Kabupaten Lima Puluh Kota, West Sumatra. There are 1,062 students. The school has only one entry point, and

the entrance opens directly onto a major national arterial road linking Payakumbuh and Pekanbaru, meaning students are in constant contact with dense, fast-moving traffic. Data from the police of Kabupaten Lima Puluh Kota shows that within five years (2018-2022), there were 472 traffic accidents in the district, with 70 deaths and 819 injuries. The road directly in front of the school ranked as the second most accident-prone with 13 accident data points [3].

Observations at the school level compound this structural risk, revealing an individual-level problem. Interviews with school staff showed that most students use motorcycles as their primary mode of transportation. However, they have poor knowledge of traffic rules, which is reflected in their irregular use of helmets, riding without a valid driving license (SIM), and poor knowledge of road signs and right-of-way rules [4]. These observations together indicate that there are three priority problems in SMAN 1 Harau: (a) insufficient knowledge and awareness of traffic rules among the students; (b) absence of a structured and sustained traffic safety education program, with the school depending on sporadic outreach activities by external entities; and (c) a dangerous surrounding environment with limited pedestrian infrastructure. These three are interlinked and together increase the level of risk that adolescent road users are exposed to in this context.

Policymakers have been aware of these mounting risks. The government has addressed this with the “Sadar Lalu Lintas Usia Dini” (SALUD) program to instill traffic discipline from an early age [5], while regional transportation agencies including Dinas Perhubungan Aceh and Dinas Perhubungan Kutai Kartanegara have run comparable school outreach initiatives [6][7]. However, government and school-based efforts are not enough; parental supervision of adolescent riding behavior is equally important [8]. More importantly, most of the current interventions in the Indonesian context are implemented as one-off seminars rather than a continuously available, school-embedded learning resource, a gap that could plausibly be filled by a low-cost, reusable, and teacher-operable medium.

Bridging this gap demands a learning approach that is both engaging and pedagogically sound. One such approach is gamification, the application of game-design elements such as scoring, competition, narrative scenarios, and immediate feedback to non-game learning contexts. According to experiential learning theory [11], the construction of knowledge is most durable when it is achieved through a cycle of concrete experience, reflective observation and active experimentation and not through passive reception of facts. This cycle is closely mirrored by a card game in which students must read a scenario, reason about the correct action, and receive immediate peer and facilitator feedback, offering a plausible mechanism by which a simple physical game could produce a measurable learning effect.

There is an increasing body of empirical work on gamified traffic safety education that supports this theoretical promise. Nawaz and Wets, in Pakistan, tested an online gamified platform for adolescent motorcyclists and found that the experimental group performed significantly better than a non-gamified control group in traffic knowledge, risk detection, and risk management [14]. Gounaridou, Siamtanidou, and Dimoulas also demonstrated that a serious game based on realistic traffic scenarios can improve the traffic behavior and safety awareness of student users [13]. Using a design directly comparable to the present study, Li, Tay, and Pustaka showed that a purpose-built traffic education game resulted in significant knowledge gains and retention in a pretest-posttest evaluation, irrespective of the gender of the participants [15].

Two Indonesian precedents demonstrate that such gains extend beyond digital platforms. The

SA-RI Card (Safe Ride Card) program showed that an increase in safety awareness can be achieved by means of a physical card-based medium among elementary school students [9], and the “Mudik Yuk” board game allowed adolescents to internalize traffic rules through interactive simulation [10]. These precedents, along with the international evidence cited above, indicate that gamified, physical, low-technology media can be as effective as their digital counterparts while being more accessible and sustainable for schools with limited infrastructure, such as SMAN 1 Harau.

The evidence above led to the development and implementation of an educational card game called Traffic Smart Card to fill the gap of traffic safety literacy at SMAN 1 Harau. The program is in accordance with the Merdeka Belajar Kampus Merdeka (MBKM) policy and has contributed to the Sustainable Development Goal (SDG) 3 (Good Health and Well-Being) and SDG 11 (Sustainable Cities and Communities). What is new in this study is the combination of a low-cost, physical, teacher-operated card medium with a rigorous pretest-posttest N-Gain evaluation in a high-risk (Indonesian secondary school) setting, a combination that has been documented less frequently than digital or simulator-based interventions in the literature. The paper describes the design and implementation of the program and the outcomes that were measured and provides an empirical estimate of effectiveness and a model that can be replicated by schools facing similar circumstances.

METHOD

Research Design

This study employed a one-group pretest-posttest (pre-experimental) design, which has been used in previous research in traffic education to measure within-subject knowledge change before and after a learning intervention [15]. The design does not have a control group, and so it cannot fully isolate the effects of the intervention from other concurrent influences, but it is suitable for an applied community service setting in which the main goal is to record the size of the change experienced by the actual partner population rather than to establish causal superiority over an alternative approach.

Participants

The research was conducted on 30 students of SMAN 1 Harau, who were selected as representative participants from classes X, XI, and XII by coordinating with the student affairs division of the school. It was voluntary, and the school presented it as an extracurricular safety education activity. The venue and facilitation capacity of a single cohort session determines the sample size, rather than a calculated statistical power target, in line with pragmatic constraints of school-based community service programs.

Instrument

Knowledge was measured with a 20-item multiple-choice test, administered identically as pre-test and post-test. The test items were distributed across three categories of traffic signs in the Traffic Smart Card: warning signs (peringatan), prohibition signs (larangan), and guide signs (petunjuk), as well as traffic ethics and licensing requirements (e.g., minimum age and SIM ownership). The item content was created by the research team in partnership with the transportation supervisor of Dinas Perhubungan Kabupaten Lima Puluh Kota to ensure that it was in line with current regulations and relevant to local riding conditions.

Traffic Smart Card Design

The Traffic Smart Card medium is a deck of illustrated cards. Each card features either a traffic sign accompanied by an open-ended question about the sign (e.g., "Explain the meaning of this sign and when a driver should be extra cautious" or "What should a driver do in this situation?") or a short traffic scenario based on real life that requires a judgemental response. Cards are sorted into the three sign categories described above, which help facilitators balance topic coverage during gameplay. The deck

was developed between June and July 2025, including content compilation, graphic illustration, question writing and printing, before passing over to the school for use in the August implementation.

Procedure

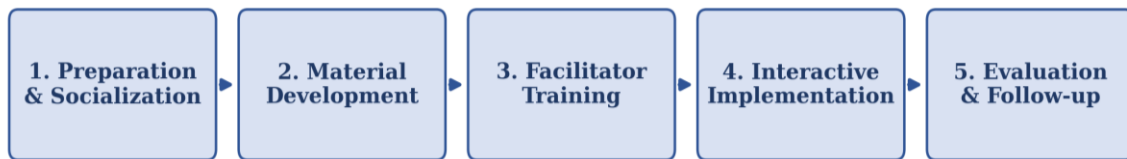


Figure 1. Implementation Stages of the Traffic Smart Card Program

Figure 1 shows that the program was implemented in five major phases. While planning and socializing, the team completed a preliminary site investigation, identified barriers through interviews with the school administration, and coordinated to gain institutional support. The road safety information was written up during the preparation of the instructional materials, and decks of road smart cards were created, printed, and handed over to the school. “During the facilitator training phase, educators and student volunteers were trained in game mechanics, scoring systems, and key traffic safety information. This course was created to standardize the facilitation of all groups.

The school auditorium hosted the interactive education program on August 18–19, 2025. It was started with a pre-test (20 multiple-choice items, about 15 minutes) and an expert talk about “Safe Riding for Students” from the transportation supervisor of Dinas Perhubungan Kabupaten Lima Puluh Kota. The 30 participants were then placed into six groups of five students to play the Traffic Smart Card game. Facilitators immediately gave remedial feedback, assessed the responses, and appraised them for accuracy and clarity. The participants took turns picking a card from the main deck, reading the scenario or question aloud, and responding verbally. The team who got the most cards correct in the time limit was the winner and was given a modest thank-you present. The identical 20-item measure was administered again as the posttest. In the final evaluation and follow-up phase of the project, we reviewed the pre-test and post-test data, compiled the documentation, and formally handed over one full set of the cards and a facilitator module to the school for ongoing autonomous use.

Data Analysis Technique

Knowledge improvement was analyzed using the Normalized Gain (N-Gain) method originally proposed by Hake [12] to compare learning effectiveness independent of students’ baseline scores. N-Gain is calculated as:

$$\text{N-Gain} = (\text{Post-test Score} - \text{Pre-test Score}) / (\text{Maximum Score} - \text{Pre-test Score}) \quad (1)$$

The resulting value was classified into three categories, summarized in Table 1, following the criteria conventionally applied in education research using Hake's normalized gain framework [12].

Table 1. N-Gain Classification Criteria

N-Gain Value	Category	Interpretation
N-Gain > 0.7	High	Substantial mastery; near-complete closure of the knowledge gap
$0.3 \leq \text{N-Gain} \leq 0.7$	Medium	Moderate improvement relative to baseline
N-Gain < 0.3	Low	Limited improvement relative to baseline

Qualitative observation was used to examine participation, behavioural indicators and verbal feedback from students, teachers and the school principal during and after the implementation, in addition to the quantitative N-Gain analysis.

RESULTS AND DISCUSSION

Pre-Test and Post-Test Results

The pre-test revealed that the participants had different levels of basic knowledge, especially with regard to questions related to the interpretation of some road signs and what to do in case of dangerous driving. The pre-test mean score was 71.17 out of 100, which needs to be targeted for assistance. All 30 students improved their post-test scores after the interactive educational program, with some students achieving a perfect post-test score of 100 and no student's post-test score declining. Figure 2: Overall increase in the class average.

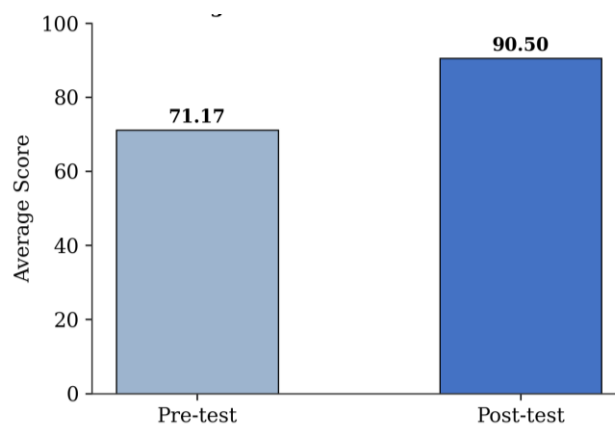


Figure 2. Average Pre-test and Post-test Scores of Participants

As shown in Figure 2, the average score of the pre-test is 71.17, and the average score of the post-test is 90.50. The average score increased by 19.33 points, or 27.17%. To look at this improvement at the individual level, rather than just the average for the class, Figure 3 shows a side-by-side comparison of each student's pre-test and post-test results.

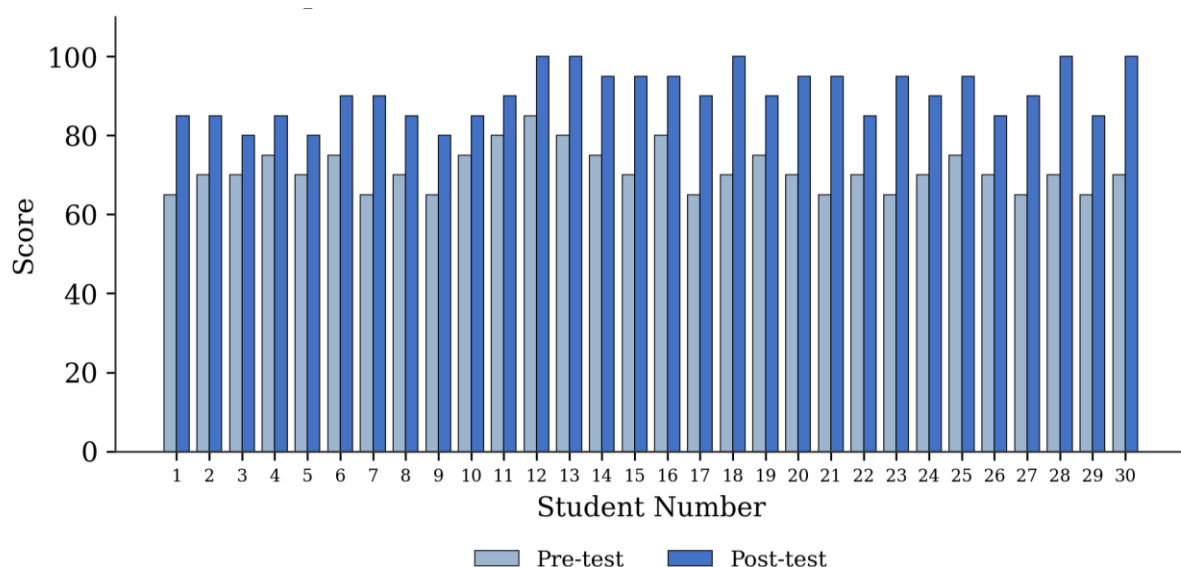


Figure 3. Comparison of Pre-test and Post-test Scores for Each Student

Figure 3 confirms that the improvement was consistent across the entire cohort: every student's post-test bar exceeds the corresponding pre-test bar, indicating that the Traffic Smart Card benefited high- and low-baseline students alike rather than disproportionately favoring those who already scored well. This pattern is consistent with findings reported by Li, Tay, and Pustaka [15], whose game-based traffic education intervention likewise produced uniform gains irrespective of participants' starting knowledge. To assess the relative magnitude of this improvement against each student's room for growth, a Normalized Gain (N-Gain) analysis was performed, yielding a class average of 0.68, which falls within the high effectiveness category according to the criteria in Table 1. Figure 4 presents the distribution of students across the three N-Gain categories.

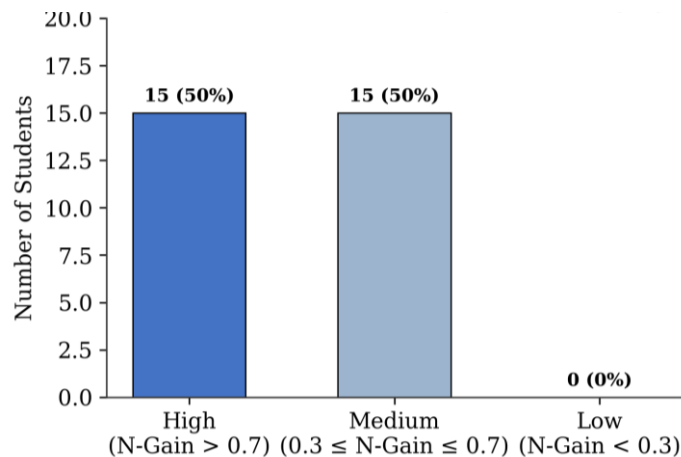


Figure 4. Distribution of Students by N-Gain Category

Figure 3 shows that all students post-test bars are higher than their pre-test bars, indicating cohort-wide gains. This suggests that the Traffic Smart Card was equally effective for children with high baseline scores as it was for students with low baseline scores. This pattern is in line with the findings of Li, Tay, and Pustaka [15], who similarly reported consistent improvements from their game-based traffic education intervention regardless of prior knowledge of the participants. To examine the relative amount of this increase to each student's potential for growth, a normalized gain (N-gain) study was performed, and a class average of 0.68 was obtained, which is regarded as high efficacy based on the criteria in Table 1. The distribution of pupils in the three N-Gain categories is presented in Figure 4.

Knowledge Domain Analysis

Further analysis of the pre-test responses revealed that the mistakes were primarily in two areas: the precise meaning of less common warning and guide signs and the correct behavioural response in ambiguous or hazardous situations such as unsignalled intersections or areas with a high density of pedestrians. In contrast, errors with obvious prohibitive signs (e.g., "No Entry") were relatively rare even at the pre-test, indicating that prohibitive signs are more intuitively understood by this age group than warning or guide signs. The post-test revealed a significant reduction in errors in the two more difficult domains, suggesting that the scenario-based card format, which asked students to reason through a situation rather than recall a definition, was particularly effective for the more conceptually difficult sign categories.

Effectiveness of the Traffic Smart Card Approach

The Traffic Smart Card was found to be very successful as a gamification method in providing

a motivating learning environment. Most of the participants were quite active in the discussions and game activities, even the children who would be inert in a normal classroom. The atmosphere was competitive but also cooperative, which encouraged peer learning and appreciation for each student's contribution.

Each card depicted a traffic issue or a road sign, and the user had to assess the situation and make a decision. For example, one student chose a card with a "No Entry" sign and described the meaning of the sign and the consequences of violating it. Students discussed the necessity of vehicles being extra cautious when they see a warning sign for a school pedestrian zone, and facilitators discussed the reality that the sign is designed to keep school-age walkers safe. Scenario-based learning ties abstract rules to real-life situations, thus enhancing knowledge retention.

The findings are consistent with past studies on gamified road safety education. Similarly, Nawaz and Wets [14] found that adolescent motorcycle riders exposed to a gamified platform learned much more knowledge and risk-related skills than a non-gamified control group, albeit their intervention was given digitally rather than with physical cards. Gounaridou, Siamtanidou, and Dimoulas [13] observed that traffic games with scenarios and a first-person perspective promoted traffic behavior and safety awareness. This approach is comparable to the scenario-driven design of the Traffic Smart Card. Kolb's experience learning theory [11] provides a reasonable explanation for the effectiveness of this style. Concrete experience is drawing a card. Reflective observation is reasoning through the scenario. Abstract conceptualization is forming a response. Active experimentation is receiving feedback from the facilitator. This completes a full cycle of experiential learning within a single, brief gaming turn, which can occur multiple times during a session.

Capacity Building of Partner Students

In addition to the gain in the overall score, the program generated capacity building in cognitive, affective, and practical domains. Cognitively, students progressed from rote recognition of signs to an understanding of the reasoning behind specific rules, e.g., why helmet use and sign compliance matter functionally rather than just procedurally. Embedded in each card turn was group discussion that also reinforced critical thinking: participants had to evaluate competing possible answers, justify their reasoning to peers, and respond to facilitator follow-up questions, a process that extends beyond simple transfer of knowledge to applied reasoning.

Affective changes observed included increased awareness of signs in everyday life and several students expressing a desire to always wear helmets and ride only with a valid SIM card. A few students took on an informal peer-educator role spontaneously, reminding their classmates about safety behavior outside the structured session. This outcome is a sign that the program effect went beyond immediate cognitive gain to a more durable attitudinal shift. In practice, the skills practiced during the card game (deciphering a sign, articulating the right response, and explaining why, all under time pressure) are directly applicable to real road encounters where similar rapid sign recognition and decision-making are needed.

Program Sustainability and Institutional Commitment

The response from students and teachers has been very positive. Participants proposed making the scenarios into cards and also a digital version to reach more people. The school principal also promised to include the Traffic Smart Card in the regular Civics learning sessions, the

School Safety Patrol (Patroli Keamanan Sekolah/PKS) extracurricular, and OSIS activities. To support sustainability, the research team provided the school with one full set of cards, a facilitator module, and digital design files so the school could reprint the cards themselves. As part of the program, SMAN 1 Harau took some additional steps: installation of basic traffic safety signs in the school surroundings, a mandate for students using motorcycles to produce a valid driving license, and an active campaign on helmet usage via the student affairs office. While one cannot attribute these downstream actions solely to the Traffic Smart Card program, the timing and thematic resonance with the intervention suggest that the program helped create broader institutional momentum around traffic safety. The team also said it would continue to provide consultation and facilitate further collaboration between the school, Dinas Perhubungan, and Satlantas in upcoming joint programs such as Police Goes to School.

Dissemination of Program Outputs

Several outputs were generated to take the programme beyond the immediate participants. The programme was featured in a regional news outlet, and a five-minute video documenting the activity was published, increasing public awareness of the initiative. A manuscript regarding the design and results of the programme is being prepared for submission to an accredited national community service journal. This contributes to the broader evidence base on the use of gamified road safety education in schools in Indonesia.

Limitations of the Study

When interpreting the results, one must consider the limitations of the present study. First, the one-group pretest-posttest design does not have a control group, so the gain observed can be attributed to anything apart from maturation, familiarity with the test, or the effect of the expert lecture delivered before the game session. Second, the sample was limited to 30 students from one school, which limits the generalizability of the results to other schools with different demographics or infrastructure. Third, the post-test was administered directly after the intervention and did not measure the longer-term retention of knowledge over weeks or months; testing for longer-term retention, as in similar studies of gamified traffic education [14], would add strength to future evaluations. Finally, behavioral change was measured by self-report and facilitator observation, rather than by direct and objective assessment of riding behavior, which is subject to social-desirability bias.

CONCLUSION

The Traffic Smart Card program was successfully implemented to increase students' knowledge and awareness of traffic safety at SMAN 1. The average post-test score of 90.50 was significantly higher by 27.17% than the pre-test average of 71.17. The average N-Gain of 0.68 shows that the program falls in the high category of effectiveness. The N-Gain distribution was 50% in the high category, 50% in the medium category, and 0% in the low category. The active participation of more than 90% of the students throughout the whole program demonstrates the ability of the method to involve the students in an inclusive way, even those who are normally passive. Alongside measurable knowledge gain, the program also contributed to affective and practical capacity building and led to independent follow-up action by the school on signage, SIM compliance, and helmet use.

Schools facing similar challenges could adopt the interactive card game approach as an effective, fun, and replicable educational tool. This is especially true for those with limited technological infrastructure, where a low-cost physical medium is more practical than digital or simulator-based alternatives. Recommendations for future development are (a) expanding the card scenario database to cover a larger range of traffic situations and all official sign categories; (b) developing a digital or mobile companion version to extend beyond in-person sessions, as requested by participating students;

(c) formally structure the School Safety Patrol (PKS) as the institutional home for continued use of the medium, with periodic refresher training for student facilitators; and (d) conduct a controlled, longitudinal follow-up study to confirm both the durability of knowledge retention and any measurable change in real-world riding behavior. Adhering to these directives would strengthen the evidence base for gamified, school-embedded traffic safety education in Indonesian secondary schools that are similarly situated.

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