Design and Evaluation of a Ubiquitous Learning Game for Adolescent E-Cigarette Addiction Prevention

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***Abstract*—This study presents the design, development, and pilot evaluation of Addict-Shield, a mobile educational serious game aimed at preventing electronic cigarette use among adolescents. The proposed approach is grounded in the DICE model (Define, Imagine, Create, Evaluate) to ensure a structured and learner-centered design process. The game integrates narrative-driven scenarios, gamification mechanics, and scientifically validated prevention content targeting risk awareness, stress management, and refusal skills. A pilot pre-test/post-test study was conducted with a convenience sample of 25 adolescents aged 12–18 years. Results indicate substantial improvements in knowledge scores (mean increase from 32% to 80%), stronger negative attitudes toward vaping, and increased behavioral intention to refuse e-cigarettes in peer-pressure situations (from 33% to 85%). Descriptive comparisons between pre-test and post-test results indicated substantial improvements in knowledge, attitudes, and behavioral intention following the intervention. Participants also reported high engagement and perceived usefulness (83–91%). Although the findings remain preliminary due to the limited sample size and absence of a control group, the results suggest the potential of structured mobile serious games for adolescent addiction prevention. These findings highlight the relevance of mobile serious games as innovative tools for adolescent addiction prevention and health education.**

***Keywords*—Serious games; mobile learning; adolescent health; vaping prevention; gamification; DICE model; pilot study**

I. Introduction

Adolescence (ages 12-18) is a phase of intense neurological development during which the brain is not yet fully mature. This neurological immaturity, combined with a quest for autonomy and increased sensitivity to social influences, makes adolescents particularly vulnerable to addictive behaviors [1][2]. Neuroscience research indicates that early experimentation with addictive substances or compulsive behaviors significantly increases the risk of addiction in adulthood, highlighting the critical need for preventive interventions during this developmental window [3][4]. Today's teenagers face a proliferation of potential sources of addiction [5]:

- Accessibility of substances: e-cigarettes, alcohol, cannabis
- Social pressure: normalization of certain consumption patterns
- Stress and anxiety: academic pressure, uncertainty about the future
- Searching for identity: experimentation as a rite of passage

Traditional prevention campaigns, such as posters, conferences, and lectures, have proven insufficient with teenagers due to low interactivity, perceived moralizing tone, and disconnection from daily life. Adolescents often understand what behaviors are risky, so merely enforcing rules rarely leads to meaningful behavioral change. Instead, prevention strategies should support adolescents in anticipating risky situations, understanding potential consequences, and making informed decisions in those contexts [6].

Serious games are digital programs designed to educate, train, or inform users through interactive experiences. By combining gameplay mechanics with educational objectives, serious games allow adolescents to safely experience risky scenarios and reflect on the consequences of their actions. These games can be developed for multiple platforms, use diverse technologies, and span a variety of genres. While entertaining, their primary goal remains to impart knowledge, develop skills, or encourage behavioral change [7][8][9].

Mobile educational games are employed in diverse contexts, including inclusion/accessibility, exact sciences, language learning, and health education. They allow for playful and contextualized exploration of knowledge, supporting modifications to traditional curricula. The wide range of gameplay mechanics demonstrates the creativity of developers in combining playful and educational elements. Through quizzes, puzzles, storytelling, augmented reality, word games, collecting activities, memory games, and social interactions, these applications offer engaging and flexible learning experiences. When well-integrated with content, these mechanics enhance learning effectiveness, relevance, and engagement across different age groups and educational needs [10]. Ubiquitous learning further extends these benefits by allowing students to learn anytime, anywhere, overcoming traditional classroom limitations and connecting learning to everyday life [11].

Serious games can also amplify intrinsic motivation to adopt positive behaviors. For example, players are guided

to manage time, adopt healthy habits, and resist smoking. By creating structured learning paths with tips, advice, and strategies, serious games provide adolescents with the motivation and framework to change behavior in a safe, experiential context. Studies have shown that serious games designed for behavior change can harness players' intrinsic motivation through engaging interactive experiences and game mechanics, thereby supporting positive health behaviors and attitude change beyond traditional informational approaches [12][13][14].

Research on gamified mobile applications and serious games for pro-environmental behaviors has shown that gamification elements such as rewards, challenges, collaboration, and immersive storytelling increase awareness and encourage the adoption of sustainable practices [15]. By analogy, these mechanisms can be applied to addiction prevention, where engagement, feedback, and decision-making scenarios can reinforce refusal skills and reflection on the consequences of risky behaviors.

The challenge addressed in this study is how to design an interactive educational mobile application that integrates appropriate social support, scientifically validated content, and engaging gamification to effectively prevent addictions among teenagers. To this end, this study presents the evaluation study of **Addict-Shield**, a mobile educational serious game aimed at preventing e-cigarette addiction in adolescents.

The main contributions of this study are threefold: 1) the design of a mobile serious game for adolescent e-cigarette prevention using a structured methodology; 2) the integration of gamified narrative elements with validated prevention content; and 3) the preliminary evaluation of the game's initial pedagogical and behavioral effects.

The remainder of this study is organized as follows: Section II reviews related work, Section III details the design methodology and game architecture, Section IV describes the evaluation protocol and results, along with a discussion, and Section V concludes by discussing the findings, limitations, and future work.

Unlike existing vaping prevention applications, this study proposes a structured pedagogical design based on the DICE model combined with an empirical evaluation in a Moroccan context, which remains underexplored in current literature.

II. Related Work

A. Tobacco and Electronic Cigarette Prevention Programs in Morocco

Several educational and prevention initiatives addressing tobacco and electronic cigarette use have been implemented in Morocco, primarily through school-based programs, public awareness campaigns, and health education interventions. These initiatives aim to inform adolescents about the health risks associated with smoking and emerging nicotine products. However, most existing approaches rely on traditional methods such as lectures, printed materials, and mass media campaigns, which often lack interactivity and personalization. Limited research has explored the use of digital or game-based educational tools for addiction prevention in the Moroccan context. This gap highlights the need for innovative, engaging, and learner-centered prevention approaches tailored to adolescents' digital habits, motivating the development of mobile serious games for addiction prevention. Serious games have been increasingly studied as interactive digital interventions that can engage adolescents more effectively than traditional media and support health promotion outcomes [16].

B. Serious Games and Vaping Prevention

The application of serious games to vaping and smoking prevention remains relatively limited, with few projects leading to fully developed and empirically evaluated game-based interventions. Most existing digital solutions focus on smoking cessation rather than early prevention and are primarily designed for adult users. Applications such as Smokitten, Kwit [17], I Am Sober [18], and Smoke Free [19] illustrate how gamification mechanisms, including progress tracking, achievements, challenges, and motivational feedback can support users during the quitting process. These tools demonstrate the potential of game-based approaches to enhance engagement, visualize behavioral progress, and sustain motivation over time.

Recent studies confirm that serious games and gamified interventions can significantly improve adolescents' knowledge, risk perception, and intention to refuse vaping [13][20][16]. A pilot randomized study showed that a social game-based tobacco prevention program increased both perceived risk of vaping and tobacco-related knowledge among adolescents [13]. Similarly, digital health game interventions have been found to strengthen smoking refusal self-efficacy and resistance to peer pressure in early adolescents [21]. More broadly, serious games have been recognized as effective tools for supporting behavior change and health education among young people.

Compared with existing smoking cessation applications, **Addict-Shield** focuses specifically on early prevention among adolescents rather than cessation support for adult smokers. In addition, unlike many existing gamified applications, the proposed system integrates a formal pedagogical design methodology (DICE model) together with narrative-based learning and behavioral skill development.

However, these applications generally emphasize self-monitoring and behavior tracking rather than structured educational content aimed at prevention. In addition, their design is rarely grounded in formal pedagogical models, and their evaluation focuses mainly on usage statistics or self-reported outcomes rather than learning effectiveness. Age-appropriate design, adaptation to adolescent needs, and the integration of educational content addressing addiction mechanisms and social pressure are often lacking. Moreover, safe and moderated social environments suitable for minors are seldom considered.

As a result, early prevention through serious games remains largely underexplored, highlighting the need for innovative mobile learning games that combine gamification, scientifically validated educational content, and structured design methodologies to effectively address vaping prevention among adolescents. To address these gaps, the present work proposes the design and evaluation of an adaptive ubiquitous learning game for adolescent e-cigarette addiction prevention, developed using the DICE model. To the best of our knowledge,

few studies have investigated serious game-based vaping prevention interventions specifically designed for adolescents in the Moroccan educational context.

III. Materials and Methods

This section presents the materials and methodology used in the pilot evaluation study. It first describes the serious game under evaluation, Addict-Shield, as well as the data collection instruments employed for the pre- and post-evaluations. This study adopts a pilot exploratory pre-experimental design without a control group, aimed at assessing feasibility and preliminary outcomes rather than establishing causal relationships. No inferential statistical tests were conducted due to the exploratory nature of the study and the limited sample size.

A. Addict-Shield: Serious Games

Addict-Shield is a mobile serious game designed to prevent electronic cigarette use among adolescents aged 12 to 18. The game is built around a narrative-driven learning approach in which players follow the journey of a fictional adolescent character confronted with social pressure related to vaping. This narrative structure serves as a pedagogical framework to contextualize educational content and decision-making situations commonly encountered by teenagers.

The game integrates several interactive modules targeting key prevention objectives, including acquisition of scientifically validated knowledge about nicotine and its effects, stress and emotion regulation strategies without substance use, and development of refusal and assertiveness skills in social contexts. Gamification mechanisms such as avatars, progression levels, achievement badges, and virtual rewards are employed to enhance motivation and engagement. Player progression is represented through a protective "shield" metaphor that visually reflects the learner's cognitive and behavioral empowerment.

B. Design Methodology: Application of the DICE Model to Addict-Shield

The design and development of Addict-Shield followed the generic DICE model, which structures the creation of digital learning experiences through four successive phases: Define, Imagine, Create, and Evaluate. This model was selected to ensure a systematic, learner-centered, and pedagogically grounded development process for an adaptive serious game dedicated to adolescent e-cigarette addiction prevention [22].

1) Define phase: The Define phase focused on identifying the target population, learning objectives, and contextual constraints. Addict-Shield targets adolescents aged 12 to 18, a population particularly vulnerable to vaping due to social pressure, misinformation, and emotional regulation challenges. The primary educational objectives were to (1) increase awareness of the health risks associated with electronic cigarettes, (2) correct common misconceptions related to nicotine, (3) develop stress management skills without substance use, and (4) strengthen refusal and assertiveness strategies in peer-influenced situations. These objectives were defined in alignment with prevention guidelines and adolescent health education principles.

2) Imagine phase: During the Imagine phase, pedagogical strategies and game concepts were designed to translate the defined objectives into meaningful interactive experiences. A narrative-driven approach was adopted to contextualize learning within realistic adolescent scenarios. The game scenario follows a fictional teenage character facing situations involving curiosity, peer pressure, stress, and social confrontation related to vaping. This narrative framework supports experiential learning by allowing players to explore consequences, make decisions, and reflect on outcomes in a safe virtual environment. Gamification elements, including avatars, progression systems, symbolic rewards, and challenges were conceptualized to enhance engagement and motivation.

3) Create phase: The Create phase involved the implementation of the serious game as a mobile application. Educational content was integrated into interactive modules addressing nicotine effects, stress regulation techniques (such as guided breathing exercises), and refusal strategies. Gamification mechanics were operationalized through levels, achievements, virtual rewards, and a visual "shield" metaphor representing the player's cognitive and behavioral empowerment. The game was designed to be intuitive, age-appropriate, and accessible, ensuring alignment between gameplay mechanics and pedagogical intentions.

The following screenshots present representative interfaces of the Addict-Shield serious game, highlighting the implementation of narrative scenarios, gamification elements, and learning modules developed according to the DICE design model.

Fig. 1 interface serves as the visual entry point to the Addict-Shield application and introduces the game's metaphorical universe centered on resistance to addiction.

- Visual Identity: The title is displayed using a medieval-inspired typeface that is consistent with the game's thematic framing. The textured, stone-like background reinforces immersion and contributes to a coherent visual atmosphere aligned with the metaphor of protection and struggle against addiction.
- The Avatar: The central armored character holding a shield represents the player's protective role and resilience against addictive behaviors. This avatar functions as a symbolic representation of empowerment, reinforcing the learner's active role in resisting risk-related situations.
- Gamification Mechanics: The presence of the "RENFORCER" button explicitly highlights the progression system of the game. It indicates that players can enhance the strength of their virtual shield by completing learning activities, such as quizzes, thereby linking educational achievement with game-based progression.

Fig. 2 marks the transition to the application's main learning activity, referred to as the Daily Quiz. It is designed to engage the user through a narrative context before the question-and-answer phase begins.

- Storyline and Avatar: The soldier avatar functions as a virtual coach rather than a purely decorative element. By directly addressing the player (e.g., "Soldier!

Fig. 1. Home screen and shield management.

Fig. 2. Quiz launch interface (core gameplay).

Ready for training?"), the interface reframes a health-related quiz as a mission to be accomplished, thereby enhancing user engagement.

- Immersive Design (RPG): The graphical composition, incorporating elements such as roots, skulls, and parchment-like textures, preserves the dark-fantasy role-playing aesthetic of the game. This artistic consistency contributes to gamifying a sensitive topic such as addiction prevention and makes it more approachable for adolescent users.
- Progression System: The Level 1 indicator displayed at the top of the screen emphasizes the notion of continuous progression and skill development, reinforcing the game-based learning trajectory.
- Call to Action (CTA): The centrally positioned and visually contrasted Start button provides a clear and intuitive invitation to initiate the Daily question-and-answer session.
- Global Navigation: The bottom navigation bar allows for seamless switching between other modules (Documentation, Quiz, Health, Profile), thus structuring the information architecture.

Fig. 3 illustrates the "Health & Wellness" section of the application. Accessible directly from the dashboard, this module addresses the immediate need for managing cravings or anxiety.

- Therapeutic Functionality: The screen offers a guided breathing exercise (similar to heart coherence) with a predefined duration of 1 minute. This short and accessible duration is ideal for quick intervention in stressful situations.
- Visual Focus: The central motif (mandala/runic circle) serves as a focal point for the user's attention. It is

Fig. 3. Stress management module (breathing exercise).

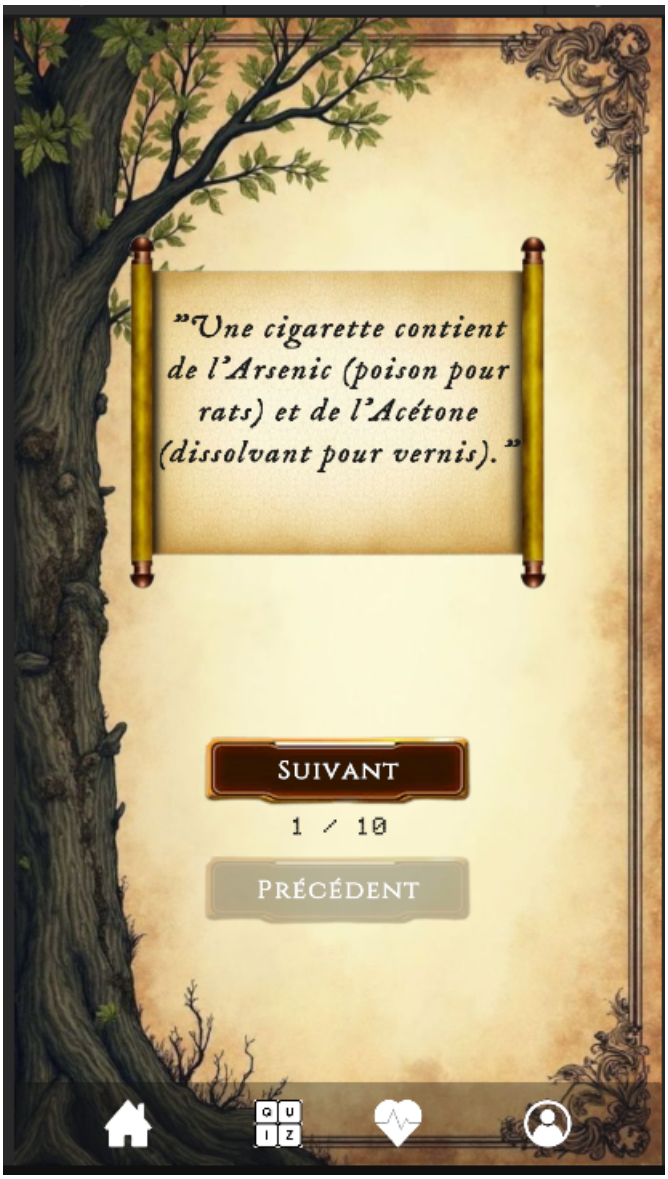

Fig. 4. Information and awareness module.

designed to animate or guide the breathing rhythm, helping the user to refocus.

- Minimalist Ergonomics: Unlike more cluttered game screens, this interface is uncluttered to avoid distracting the user. The "READY?" question and the "START" button launch the activity seamlessly.
- Graphic Consistency: Even for a utility tool, the textured background and typography are preserved, keeping the user in the secure universe of the application.

Fig. 4 represents the educational component of the application. Its purpose is to inform the user about the dangers of addictive substances through striking and scientifically verified facts.

- Micro-Learning (Rapid Learning): Information is broken down into small, digestible fragments (here, one quote per page). The "1/10" counter clearly indicates the content length, encouraging the user to read to the end without feeling overwhelmed by a lengthy medical text.
- Psychological Impact: The chosen text ("Arsenic", "Acetone") uses striking comparisons (rat poison, solvent) to make an impact and deconstruct the commonplace image of cigarettes.
- Universe Consistency: The design of the scroll unfurled against a natural background (tree) maintains the "Fantasy" immersion. The user doesn't feel like they are reading a lecture, but rather discovering "ancient knowledge" or clues for their quest.
- Intuitive Navigation: The interface was designed to ensure intuitive navigation and maintain user engage-

ment throughout the learning experience.

4) Evaluate phase: The Evaluate phase consisted of assessing the pedagogical effectiveness of **Addict-Shield** through a user-based evaluation. The game was tested with a target adolescent audience using pre- and post-evaluation questionnaires. The evaluation focused on measuring changes in awareness of e-cigarette risks, knowledge acquisition, and behavioral intention regarding vaping. This phase aimed to verify whether the serious game effectively achieved its educational objectives and to identify areas for improvement in both content and game design.

C. Study Design and Evaluation Protocol

This study follows a pre-experimental pre-test/post-test design to evaluate the pedagogical effectiveness of the **Addict-Shield** serious game. The evaluation focuses on assessing adolescents' awareness and knowledge of e-cigarette risks, their ability to manage stress without substance use, and their behavioral intention toward vaping refusal.

Participants were invited to complete a pre-evaluation questionnaire prior to interacting with the game. They then engaged with the game during a structured gameplay session using mobile devices. Following the intervention, a post-evaluation questionnaire was administered to measure potential changes in the targeted learning outcomes.

The study was conducted in a controlled educational setting to ensure consistent conditions across participants. Ethical considerations were respected, with voluntary participation, parental consent, and anonymous data collection.

As an exploratory pilot study, the evaluation aimed to assess feasibility and preliminary pedagogical effects rather than establish definitive causal relationships.

D. Participants

The pilot study involved a convenience sample of N = 25 adolescents aged between 12 and 18 years. Participants were recruited from a secondary school context and voluntarily agreed to take part in the study. Inclusion criteria required participants to be within the target age range and to have access to a smartphone capable of running the mobile application.

Prior to participation, informed consent was obtained from parents or legal guardians, and assent was collected from the adolescents. Participation was voluntary, and all data were collected anonymously in accordance with ethical guidelines for research involving minors. The convenience sampling approach was considered appropriate for this preliminary pilot evaluation but may limit the generalizability of the findings.

E. Data Collection Instruments

Data were collected using a set of pre- and post-evaluation questionnaires designed to assess the targeted learning outcomes of the proposed serious game. The instruments were structured into five sections: (1) Demographic information was collected to characterize the study sample, including age, gender, and prior exposure to electronic cigarettes (see Appendix A). (2) Awareness and knowledge related to electronic cigarette use and nicotine effects were assessed through a short questionnaire composed of multiple-choice and true/false questions (see Appendix B). (3) Self-reported stress and emotion regulation strategies without substance use were measured using Likert-scale items (see Appendix C). (4) Behavioral intention to refuse vaping in social situations was evaluated through scenario-based statements reflecting common peer-pressure contexts (see Appendix D).

In addition, (5) a post-intervention questionnaire was administered to assess participants' perceptions regarding engagement, usability, and perceived usefulness of the game. All instruments were administered anonymously before and after the gameplay session(see Appendix E).

F. Evaluation Metrics

The evaluation of Addict-Shield was based on a pre-test/post-test comparison framework designed to assess the pedagogical effectiveness of the serious game. The evaluation metrics focused on three main dimensions aligned with the educational objectives of the game.

- Knowledge acquisition: Participants' knowledge regarding electronic cigarettes and nicotine-related risks was assessed using a set of multiple-choice and true/false questions administered before and after the intervention. These items evaluated factual understanding of nicotine effects, addiction mechanisms, and common misconceptions related to vaping. Knowledge scores were calculated as the total number of correct responses.
- Attitudes toward vaping: Attitudinal changes were measured using Likert-scale items assessing participants' perceptions of the harmfulness of electronic cigarettes, perceived social acceptability, and personal beliefs regarding vaping. Higher post-test scores reflected more negative attitudes toward e-cigarette use.
- Behavioral intention and resistance to peer pressure: Behavioral intention was evaluated through scenario-based questions examining participants' likelihood of refusing e-cigarettes in socially challenging situations. These items were designed to assess assertiveness and resistance to peer pressure, which are central objectives of the Addict-Shield game design.

For each dimension, pre-test and post-test scores were compared to identify trends in learning outcomes and behavioral intention. Given the exploratory nature of this pilot study and the limited sample size, the statistical analysis aimed to identify preliminary trends rather than establish definitive causal conclusions. Descriptive statistics (means, standard deviations, and percentages) were computed to summarize participants' responses and identify preliminary trends between pre-test and post-test evaluations.

1) Data analysis method: Data collected from the pre- and post-evaluation questionnaires were analyzed using descriptive statistical methods, in direct alignment with the evaluation metrics defined for this study. For each evaluation dimension, mean scores and standard deviations were computed to summarize participants' responses before and after the intervention.

First, knowledge acquisition related to electronic cigarettes and nicotine risks was analyzed by calculating the total number of correct responses to the multiple-choice and true/false items administered at pre-test and post-test. Pre-/post-comparisons were used to observe trends in factual understanding and awareness of vaping-related risks.

Second, attitudes toward vaping were analyzed using Likert-scale items assessing perceived harmfulness, social acceptability, and personal beliefs regarding electronic cigarette use. Changes in mean attitude scores between pre- and post-evaluations were examined to identify shifts toward more negative perceptions of vaping.

Third, behavioral intention and resistance to peer pressure were analyzed through scenario-based items reflecting common social situations involving vaping. Participants' likelihood of refusing e-cigarettes was summarized using descriptive statistics, and pre-/post-trends were examined to assess changes in assertiveness and refusal intention.

Given the exploratory nature of this pilot study and the limited sample size, the analysis primarily aimed to explore trends and feasibility rather than to draw definitive causal conclusions or conduct advanced inferential statistical tests. Additionally, qualitative feedback collected through open-ended post-intervention questions was analyzed using a simple thematic approach to capture participants' perceptions, engagement, and overall experience with the Addict-Shield serious game.

Although the sample size was limited (N=25), percentage-based comparisons were considered appropriate for this exploratory pilot study aiming to assess feasibility and observable trends rather than statistical generalization. The study serves as a preliminary step toward larger-scale controlled investigations. Descriptive statistics (means and percentages) were used to summarize the data.

IV. Results and Discussion

A. Participant Demographics

Table I summarizes the demographic characteristics of the 25 adolescents who participated in the pilot study. Participants were aged 12–18 years, with 36% (n=9) aged 12–14 and 64% (n=16) aged 15–18. Females represented 56% (n=14) of the sample. Six participants (24%) reported having ever tried e-cigarettes, and 10 (40%) reported having friends who vape. All participants owned or regularly used a smartphone (100%). The sample was obtained using a convenience sampling approach due to the exploratory nature of the pilot study.

TABLE I. Demographic Characteristics of Participants (N = 25)

Variable	Category	n	%
Age	12–14 years	9	36%
	15–18 years	16	64%
Gender	Male	11	44%
	Female	14	56%
Ever tried e-cigarette	Yes	6	24%
	No	19	76%
Friends who vape	Yes	10	40%
	No	15	60%
Own or regularly use a smartphone	Yes	25	100%
	No	0	0%

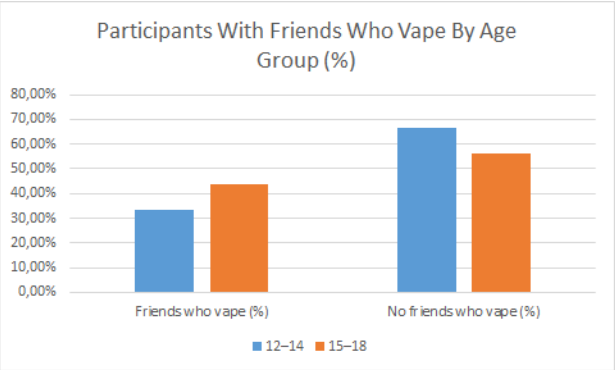

Fig. 5. Participants with friends who vape by age group.

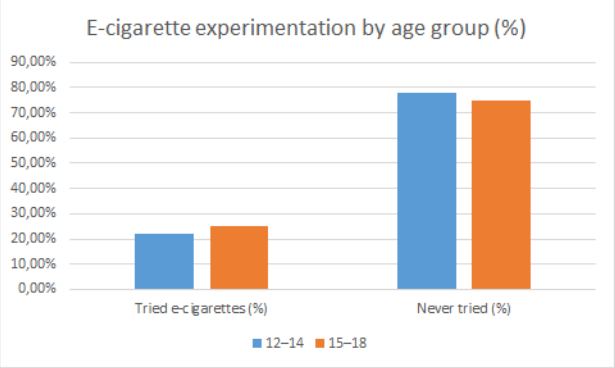

Fig. 6. Participants who tried e-cigarette by age group.

B. Social Exposure and E-Cigarette Experimentation

Fig. 5 presents the proportion of participants reporting having friends who vape, stratified by age group. Social exposure was slightly higher among older adolescents, with 43.8% of participants aged 15–18 reporting friends who vape compared to 33.3% in the 12–14 age group. In both groups, the majority of participants reported not having friends who vape (66.7% and 56.2%, respectively).

Fig. 6 reports the distribution of participants according to e-cigarette experimentation status by age group. Most participants reported never having used e-cigarettes (77.8% in the 12–14 group and 75% in the 15–18 group). A small proportion reported prior experimentation (22.2% and 25%, respectively).

C. Knowledge Acquisition and Awareness

Fig. 7 presents pre-test and post-test scores related to participants' knowledge and awareness of e-cigarettes and nicotine effects. Pre-test scores ranged from 23% to 41%, while post-test scores ranged from 75% to 85%.

Descriptive analysis shows an increase in post-test scores compared to pre-test scores. Given the exploratory design of the study, the small sample size (N=25), and the absence of a control group, these results should be interpreted as preliminary descriptive changes rather than evidence of intervention effectiveness.

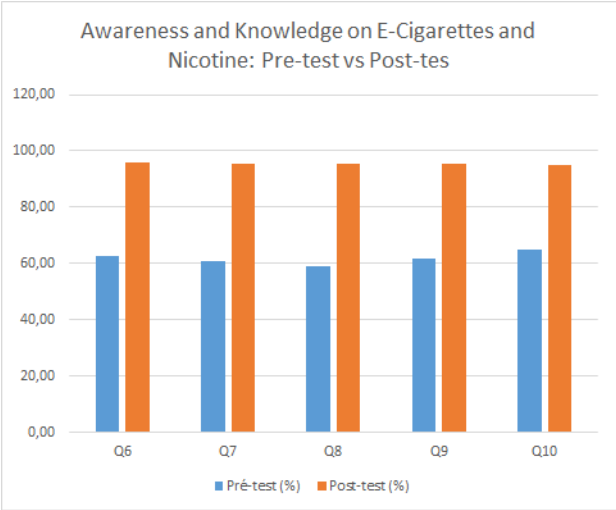

Fig. 7. Changes in awareness and knowledge about e-cigarettes and nicotine before and after intervention.

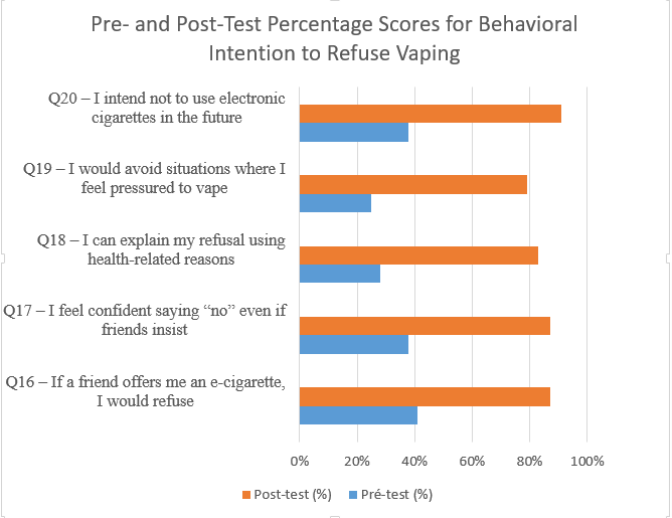

Fig. 8. Pre- and post-test percentage scores for behavioral intention to refuse vaping.

D. Behavioral Intention and Resistance to Peer Pressure

Fig. 8 presents pre- and post-test scores for participants' behavioral intention to refuse vaping in socially challenging situations. Scores increased from 25–41% at pre-test to 79–91% at post-test.

These results indicate higher post-intervention scores in behavioral intention measures. Given the exploratory design of the study, these findings are reported as descriptive changes without implying causal effects.

E. Engagement, Usability, and Perceived Usefulness

Fig. 9 presents participant ratings related to engagement, usability, and perceived usefulness of the game. Scores ranged from 83% to 91% across items assessing enjoyment, realism, and educational value.

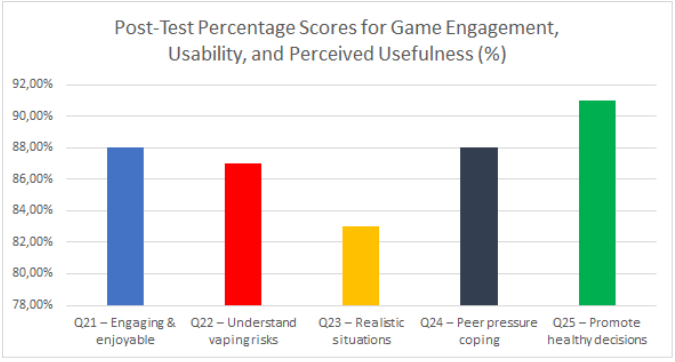

Fig. 9. Pre- and post-test percentage scores for game engagement, usability, and perceived usefulness.

These results indicate generally high self-reported engagement and perceived usefulness of the game.

F. Summary of Results

The main findings of the pilot study can be summarized descriptively as follows:

- Knowledge scores increased from 32% (pre-test) to 80% (post-test).
- Behavioral intention to refuse vaping increased from 33% to 85%.
- High levels of engagement and perceived usefulness were reported (83%–91%).

These results are reported as descriptive outcomes of a pilot exploratory study without inferential statistical testing.

G. Discussion

The pilot findings suggest that **Addict-Shield** may have potential to improve adolescents' knowledge and behavioral intentions regarding e-cigarette use. However, these findings should be interpreted cautiously due to the exploratory design of the study.

The observed increase in post-test scores are consistent with previous research on serious games for health education, which highlights the effectiveness of interactive and narrative-based learning approaches [20], [16]. Nevertheless, in the absence of a control group, it is not possible to attribute observed improvements exclusively to the intervention.

The small convenience sample (N=25) further limits generalizability, and results may not be representative of the broader adolescent population. In addition, short-term measurement prevents assessment of long-term behavioral impact.

Despite these limitations, the study demonstrates the feasibility of implementing a mobile serious game for vaping prevention in an educational context. The findings support the potential value of gamified and experiential learning approaches compared to traditional didactic methods[21][23][24].

Future research should employ randomized controlled designs with larger samples and long-term follow-up to validate the effectiveness of the intervention and strengthen causal inference.

H. Limitations

This study presents several limitations. First, the pilot evaluation relied on a relatively small convenience sample (N = 25), which limits the generalizability of the findings. Second, the absence of a control group prevents strong causal interpretation of the observed improvements. Third, the study evaluated only short-term effects immediately after gameplay and did not assess long-term behavioral retention. Future research should therefore involve larger randomized controlled trials with longitudinal follow-up and more diverse participant populations.

V. Conclusion

This pilot study demonstrates the feasibility of Addict-Shield as a structured mobile serious game for adolescent e-cigarette prevention. The DICE-based design framework enabled the integration of pedagogical objectives, narrative immersion, and gamification mechanics within a coherent learning experience.

The results indicate positive short-term changes in participants' knowledge, attitudes, and behavioral intentions following the intervention. However, given the exploratory design, small sample size, and absence of a control group, these findings should not be interpreted as evidence of effectiveness.

Rather, they suggest the potential of mobile serious games to complement traditional prevention strategies by enhancing engagement and experiential learning.

Future research should involve randomized controlled trials with larger samples and longitudinal follow-up to assess sustained impact and causal effectiveness, as well as explore adaptive personalization mechanisms.

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Appendix

This appendix presents the complete questionnaire used in the pilot study to evaluate the **Addict-Shield** serious game. Appendix A to Appendix D were administered both before and after gameplay, while Appendix E was administered only after the intervention.

A. Demographic Information (Pre-test only)

1) Age:
   - 12
   - 13
   - 14
   - 15

- 16
- 17
- 18

2) Gender:
   - Male
   - Female
   - Prefer not to say
3) Have you ever tried an electronic cigarette (vape)?
   - Yes
   - No
4) Do you have friends who use electronic cigarettes?
   - Yes
   - No
5) Do you own or regularly use a smartphone?
   - Yes
   - No

B. Awareness and Knowledge About Electronic Cigarettes and Nicotine (Pre-test and Post-test)

6) Nicotine is mainly:
   - A calming substance
   - A psychostimulant
   - Harmless for teenagers
   - I don't know
7) Electronic cigarettes may contain toxic substances harmful to health.
   - True
   - False
   - I don't know
8) Using electronic cigarettes during adolescence can increase the risk of addiction later in life.
   - True
   - False
   - I don't know
9) Flavored electronic cigarettes are designed to attract young users.
   - True
   - False
   - I don't know
10) Nicotine can affect brain development in adolescents.
   - True
   - False
   - I don't know

C. Stress and Emotion Regulation Without Substance Use (Pre-test and Post-test)

Responses are rated on a 5-point Likert scale (1 = Strongly disagree, 5 = Strongly agree).

11) I am able to manage stress without vaping or smoking.
12) I know healthy ways to calm myself when I feel anxious (e.g., breathing, relaxation).
13) Using nicotine is not necessary to reduce stress.
14) I feel confident in my ability to control my emotions.
15) Stress can be managed effectively without addictive substances.

D. Behavioral Intention to Refuse Vaping in Social Situations (Pre-test and Post-test)

Responses are rated on a 5-point Likert scale (1 = Strongly disagree, 5 = Strongly agree).

16) If a friend offers me an electronic cigarette, I would refuse.
17) I feel confident saying "no" even if my friends insist.
18) I can explain my refusal using health-related reasons.
19) I would avoid situations where I feel pressured to vape.
20) I intend not to use electronic cigarettes in the future.

E. Game Engagement, Usability, and Perceived Usefulness (Post-test only)

Responses are rated on a 5-point Likert scale (1 = Strongly disagree, 5 = Strongly agree).

21) The game was engaging and enjoyable.
22) The game helped me better understand the risks of vaping.
23) The situations presented in the game felt realistic.
24) The game helped me learn how to deal with peer pressure.
25) I think this game can help adolescents make healthier decisions.