SMARTCOP – AUTOMATED PLATFORM TO MITIGATE THE IMPACT OF ROAD ACCIDENTS

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DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. Also, I hereby grant to Sri Lanka Institute of Information Technology, the non-exclusive right to reproduce and distribute my dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

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The above candidate is carrying out research for the undergraduate dissertation under my supervision.

Signature of the supervisor

[Dr. Windhya Rankothge] Date

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ABSTRACT

The inadequacy of awareness on road safety rules and ethics among the community causes to increase road accidents. As implied by the saying “Prevention is better than cure”, accident prevention endeavors will support to limit the impact of road accidents. Therefore, proper evaluation of people’s road accident prevention awareness is vital. Nevertheless, conventional methods for gaining knowledge on road safety are not very impressive for many people. Hence, a much appealing, novel and efficient procedure is needed. Among the technology-based strategies that have been addressed so far, one satisfying procedure is the use of Game Based Learning to heighten road accident prevention awareness among the community. This study intends to investigate whether competencies obtained through Game-Based Learning activities are more beneficial to learn and retain knowledge on road safety compared to conventional techniques. This research will recognize the essential competencies required for accident prevention and an appropriate mobile game will be developed which will address most of the causing factors for road accidents. The identified competencies will be used for the effective instruction of road safety best practices through repetition, failure and the accomplishment of goals within the game. This study will especially consider the personalization of game experience according to an individual player’s skill level and playing style by the use of Machine Learning to achieve Dynamic Difficulty Adjustment of game levels. This approach will keep the players engaged in game playing, encourage them to learn and retain knowledge which will eventually result in enhancing situational awareness. Consequently, the proposed game will demonstrate how users’ progress of road accident prevention awareness level has improved throughout various attempts. Additionally, it will allow police officers to inspect overall public awareness reports and will assist them in proper decision making for mitigating the impact of road accidents through the means of improving road accident prevention awareness.

Keywords: Road accident prevention, road safety awareness, Game-Based Learning, personalized game experience.

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LIST OF ABBREVIATIONS

Abbreviation	Description
ML	Machine Learning
SVM	Support Vector Machine
LR	Logistic Regression
IDE	Integrated Development Environment
API	Application Programming Interface
GUI	Graphical User Interface

LIST OF APPENDICES

1. INTRODUCTION

1.1. Background and Literature Survey

1.1.1. Background

The number of deaths due to road accidents in Sri Lanka reached 3554 as per the latest World Health Organization (WHO) data published in 2017. Insufficient exposure and consciousness among populations about traffic environments and rules cause the growth of road accident statistics [1]. Exceeding speed limits, driving under the impact of alcohol and other psychoactive substances, non-use of motorcycle helmets, seat-belts, and child restraints and distracted driving are the primary risk factors for road traffic injuries [2]. Therefore, improving the knowledge of road rules and ethics among communities seems crucial in consequence of consistently incrementing road accidents. Nevertheless, the common methods for acquiring knowledge on road safety best practices are not satisfying to young drivers seeking licenses or to most drivers as a way to refresh their knowledge after they have obtained their drivers' licenses [3]. Hence, a more innovative, appealing and effective strategy for educating road safety best practices is necessitated [4].

Among the several kinds of research that have been conducted so far, one of the finest technology-based strategies is applying Game-Based Learning for sharpening road accident prevention awareness among the community. Studying via digital games is not only more productive but also involves a fascinating learning procedure, which encourages users' inherent urge to play, enhances users' autonomous training time and offers them feedback that will boost their remembrance [5]. G. R. Dange et al. [6] observed that games can benefit the users in understanding and to reform rigid driving habits through a pleasant medium. Also, according to A. Azadeh et al. [7], the quality of the decision-making process of drivers could have a vital impact on preventing disasters. On the other hand, K. Bochennek et al. [8] state that, in an unconstrained context, games may mimic manners of decision-making and can

intensify teaching schemes. Thus, Game-Based Learning resembles to be an assuring strategy for heightening road safety awareness among the community. Therefore, a survey has been conducted to recognize both the demand for this proposal and the fundamental measures to be examined in this project.

Figure 1.1: Survey responses for what people think about applying Game Based Learning for improving traffic rules and road safety ethics awareness.

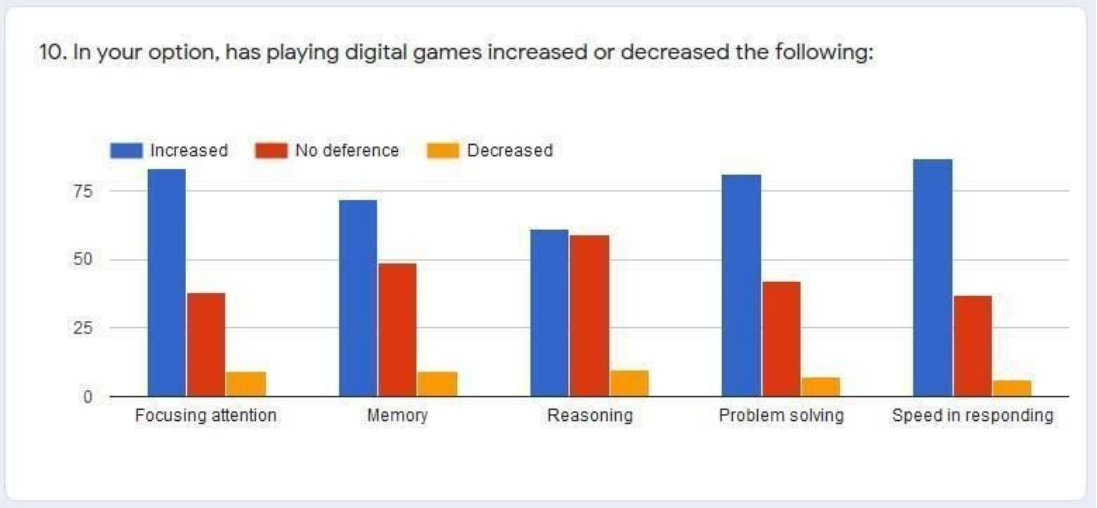


Figure 1.2: Survey responses for how people think that digital games affect their competencies.

As depicted by Figure 1.1 and Figure 1.2, it is obvious that Game Based Learning will be a promising approach for sharpening road accident prevention awareness among the community. Therefore, this research proposes to develop a mobile game and explore the influences of Game-Based Learning on people's attainment and retention of road safety best practices. Additionally, with the aid of Machine Learning, this study will primarily consider the personalization of game experience according to a specific player's skill level and playing style to keep the players more engaged in game-playing and encourage them to learn through repetition, failure and the accomplishment of goals. In addition to contributing to the existing literature, this research will provide information on overall public awareness level to the police and individual awareness progress evaluations for players of the proposed game to effectively mitigate the impact of road accidents.

1.1.2. Literature survey

For this research, the concept of gamification, which is best defined as the application of game design components in non-game circumstances will be focused on. [28]. There is a body of studies endeavoring to illustrate how and why we should apply games in training. In terms of applying Game-Based Learning for road safety instruction, several strategies have been suggested.

M. Hussin and N. Hanis Mohd Fouzi [1] attempted to increase road safety awareness among children by using computer games as a learning medium. They used Road Safety Flash Games developed by the Road Safety Unit (JKJR) [23]. They arranged a Pre-test and a Post-test which distributed to participants respectively before and after playing the game. The findings show that the game had raised their overall awareness of road safety and made it easy to understand and memorize road signs, road safety policies, and rules. However, this study involves a merely small number of respondents who were limited to specific age groups and this study only examines how the games act as a practical learning tool. Yet, not only this work determines

that there is significant progress of awareness on the road rules and conditions after usage of games, but also the directions for future work such as concerning the large, varied sample size and wider location are also addressed.

H. Arbogast et al. [15] developed the first randomized study examining a novel educational video game about pedestrian safety to conventional didactic learning. They hypothesized that children revealed to a computer-based video game would correspond at least as well to children who experienced these same lessons via regular didactic training. To test this hypothesis, they conducted a randomized investigation examining the behavior of these two gatherings on a life-size simulated street. The results indicated that participants who played the video game scored at least as well on the simulated street as those who attended a didactic lecture. Moreover, on certain pedestrian behaviors, kids who were randomized to the game performed better than kids randomized to the didactic training. However, the main shortcoming of this research is that learners were experimented for any variation in awareness or enhanced behavior shortly after being exposed to the intervention and were not examined for knowledge retention. In addition, playing the game was a challenge for several students because of the language barrier and also some of them had little previous exposure to video games and may have been focusing on the gameplay rather than the tutorings included within. Nevertheless, this study suggests that electronic games can possibly present an innovative mechanism for the field of pediatric injury mitigation and can also make these teachings globally attainable.

E. Lehtonen et al [17] developed a learning game that could educate children better situation awareness (SA) in traffic in a safe atmosphere. They also designed a test for the evaluation of situation awareness and using a crossover/switching replications design they examined whether the learning game enhanced SA. Although it was not feasible to conclude that the learning game would be an efficient way to instruct situation awareness/risk perception for child bicyclists by the research outcomes, the situation awareness experiments were able to capture that the non-obvious, clandestine targets (occlusions) were particularly complicated for children. Furthermore, the game playing duration was insufficient in this study and the necessity for the research on more long term exposure for expressing an

enhancement in sensitivity has also been noted. Above all, compared to the point-and-shoot sort of games, the demand for the games which require more 'thinking' for the attainment of situational awareness has been emphasized.

G. R. Dange et al [6] illustrated the use of the gaming approach in the automotive domain to boost green and safe driving habits. They used the serious game concept to formulate various game strategies (competitive and immediate feedback) to heighten driver performance. Moreover, they carried out field tests to understand the indications of gaming in a real-time situation. A good perception of the circumstances concerning tool configuration, safety, and usability has been presented by the responses from the field tests. In the aspect of future challenges, the necessity for carrying tests with more extra users in numerous situations and gaining more collaborative perspectives in the game, by producing improvements in competition procedure (stage competitions) has been mentioned.

K. Szczurowski and M. Smith [5] described one possible strategy for utilizing game-based learning into road safety instruction. They developed a computer-supported training system that strives to address psycho-motor talents associated with crossing a road safely, changing learners' attitudes towards road safety best practices, and allowing the self-supporting practice of transferable abilities. Although the product never went past the prototype stage and all evaluations made were informal, mainly focused on usability, and did not include enough sample size to yield any kind of statistically notable outcomes; the feedback from both parents and kids who playtested the game has been overwhelmingly optimistic. It appeared that the parents were very excited about seeing games produced for instructional purposes and they see the benefit in addressing road safety procedural knowledge through a Virtual Reality application. However, the requirement for a more structured and precise study to verify these findings has been indicated.

S. Wimaladharma et al. [19] developed a game-based procedure where players receive the ability to play a game that is comparable to modern car games + vehicle simulators. The system provides a realm virtual environment to the player who plays

the game along with a self-evaluation about their own driving talents. However, including all the driving rules and regulations, attaching traffic police like non-player characters and appending a choice to customize the player vehicle are highlighted as future work.

DC. Schwebel et al. [16] carried out a pre-post within-subjects trial of coaching kids in pedestrian safety utilizing a semi-mobile, semi-immersive virtual pedestrian atmosphere arranged at schools and community centers. They initially estimated pedestrian safety skills among kids and then let children complete practice sessions in the virtual pedestrian atmosphere following pragmatic trial approaches over the course of three weeks. Following practice, pedestrian safety talents were re-assessed. Results symbolize that although performance in making a choice to enter the road was developed, the safety of crossing was not altered notably after exercise. Ultimately, the findings recommend virtual reality settings placed in community centers hold encouragement for training kids to be safer pedestrians, but the necessity for future research to continue to investigate the effectiveness and dosage needed to efficiently instruct kids in pedestrian safety applying virtual reality environments have been reminded.

S. Ismail et al. [20] studied the effectiveness of coaching traffic signs by a game-driven interface. A game consists of a quiz mode and a car game mode was developed by them. They inserted problems about the traffic laws in the goal-oriented car driving game. Their findings reveal that the game is a more practical method compared to using the conventional method for studying the traffic signs. They believe that the engagement level is the foremost reason behind the game participants obtaining higher traffic law awareness. Including all traffic law rules and regulations, examining the long term impact of playing the game regularly on participant driving performance are drawn attention as future work.

I. Dunwell et al. [21] performed an evaluation of a game-based strategy endeavoring to enhance the road safety habits among kids, made accessible outside of a classroom setting as an online, browser-based, free-to-play game. Their findings propose that the wide-scale deployment of digital games for training can attract and retain a

sizable public for a session likely to exceed that potential through more static web-based intervention or other media such as television broadcasting. However, the challenge in communicating and building significant social ties affecting the limited exposure times of players to the game is one of the notable difficulties they have encountered.

M. A. F. Rodrigues et al. [22] intended to familiarize motorists with laws of safe driving and acquaint them with the traffic laws and regulations. They produced an interactive and educational 3D traffic rules game controlled by non-traditional devices (steering wheel, joystick, tablet, and smartphone), besides the usual keyboard. They have handled user-based evaluations using different control devices to achieve a quantitative and qualitative analysis of the game. The results explained that although some input devices propitiated a more stimulating game playing and studying practice to users than others, the serious game provided activities that delivered moments of fun, achievement while guaranteeing motivation and learning. For future work, the addition of forms of reward, evaluations, sharing of ranking scores in social networks is identified.

Apart from this immense number of existing serious games and driving simulators, there are also several educational memory games (mostly quizzes) aimed at the traffic laws and regulations [24] – [27]. However, those are not much capable of engaging and retaining players, have not acknowledged the dynamic adaptive game level difficulty and are currently limited to only delivering and assessing declarative knowledge. Thus, this study further investigated on most suitable game genres for intensifying user engagement when learning through games. Q. Li and R. Tay [3] discovered that when learning through games, the focus of training should be problem-solving in order to keep the player constantly engaged. On the other hand, findings of X. Chen [31] implies that among most popular genres such as action games, adventure games, puzzle games, role-playing games, and strategy games, puzzle games were seen as an indicator of successful gamers for rising problem-solving skills. Moreover, according to S. Heintz and E. L. C. Law [32], puzzles provide problems, which encourage the learner to apply prior knowledge and gain new knowledge while solving them. In addition, this study carried out a survey

to identify the most preferred game type among people. Since most of the currently available educational solutions are quizzes and are limited to assessing declarative knowledge as per the above review, ultimately the second highest preference (refer Figure 1.3); a "Hangman Game" was decided to be developed in order to deliver and assess procedural knowledge, enhance people's problem solving skills while achieving more user engagement.

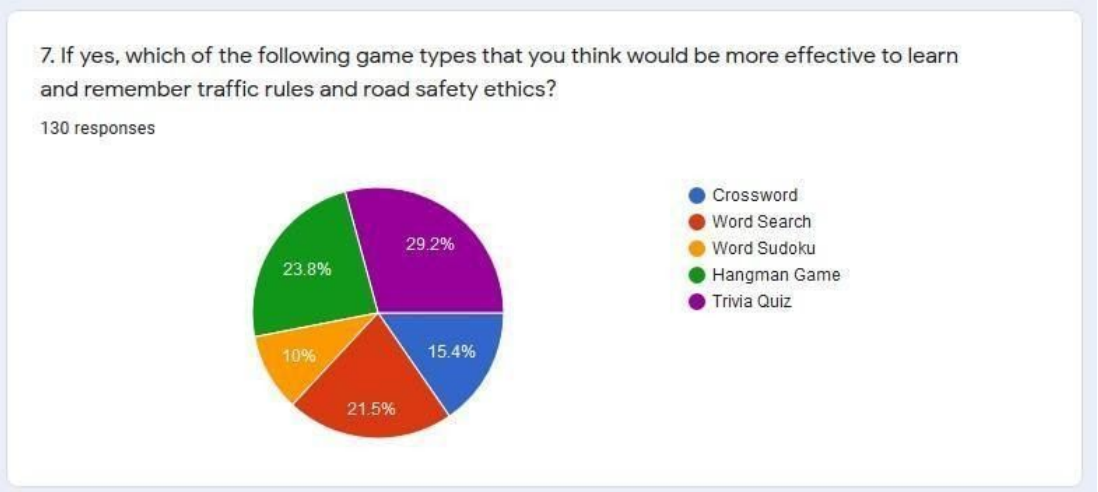


Figure 1.3 Survey responses on people's preferred game type for learning and remember traffic rules and road safety ethics.

1.2. Research Gap

A review of the literature reveals that most of the researchers have focused on children's education [1] or the respondents were limited to a specific age group [4]. Furthermore, several studies were conducted in just one city; therefore, the research results have yet to be generalized [15]. Also, instead of jointly examining all the main contributory circumstances, several studies have only investigated the impact of a few of the chosen factors [7]. Moreover, for some participants, playing the game was a challenge because they had little previous exposure to video games and may have been focusing on the game play rather than the lessons included within [15]. Figure 1.4 reveals the summary of survey responses for the challenges people encounter when they play digital games. As well as for the study results of some

studies, the language barrier has also influenced participants' reading comprehension [15]. Apart from that, in certain studies the game playing duration was insufficient and it is required to study more long term exposure to studying through games for illustrating an improvement in sensitivity [17].

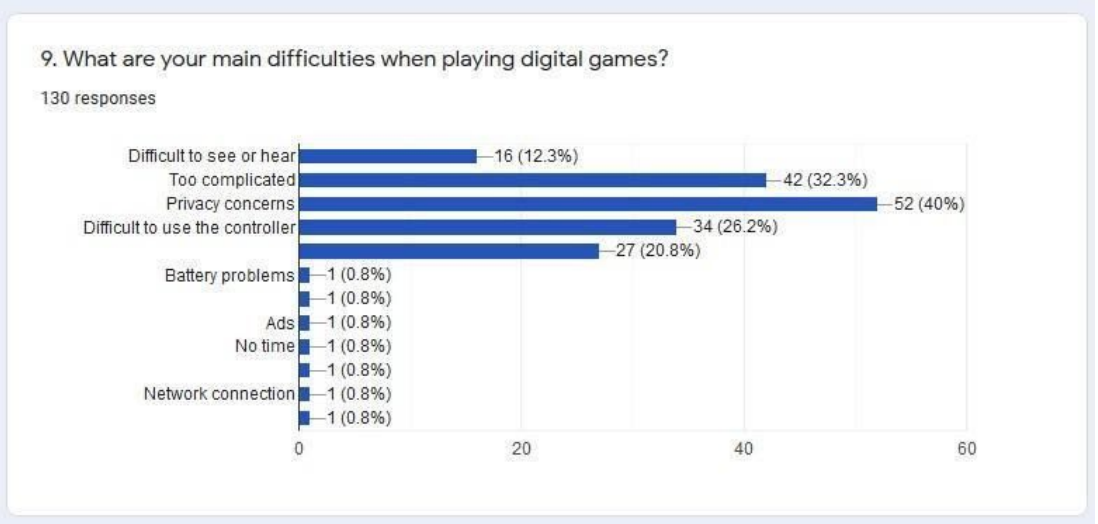


Figure 1.4: Survey responses for what people find challenging when they play digital games.

One the other hand, some of the research has tested for any variation in awareness or enhanced performance shortly after being exposed to the intervention and have not experimented for knowledge retention [15]. Plus, the collaborative aspect promotes the exposure of a system and adaptability, gaining more collaborative aspects in games also should be considered [6]. Nevertheless, several studies only review how the games act as an efficient learning mechanism and therefore, research on how the games change the human behaviors also needs to be conducted[4]. Despite the notable number of studies in traffic accidents and road safety topics, the studies that discussed the interaction relationship between the drivers' behavior in terms of their historical recordings of traffic violation and accident involvement are comparatively few in the literature [29]. On top of that, the majority of the studies have paid little consideration to investigate the outcomes of the knowledge test, especially road rules, on driving behavior, violations, crashes, etc. and mainly focused on vehicle handling talents and on-road driver practice [3].

The study of the literature points out that no research has been carried to recognize drivers' dominant decision-making techniques and to establish the relationships between decision-making methods and injury severity of road accidents [7]. Still, most of the existing games [9, 10, 11, 12, 24, 25, 26, and 27] have not acknowledged dynamic difficulty adjustment in-game levels according to particular user's skill levels and also those games were merely developed only to test user awareness and not used game results with traffic police for road accident prevention. Although there is a high potential for interaction being common in Virtual Environments, available game-based solutions to road safety education are currently narrowed to presenting and evaluating declarative knowledge [5]. Besides, compared to the point-and-shoot sort of games, the demand for the games which require more 'thinking' for the attainment of situation awareness has often been pointed out [17]. Figure 1.5 compares key features of the proposed system along with currently available games.

Features	Road Signs Game [24]	Pic Quiz: Road Signs [25]	Pinoy Road Signs Quiz Game [26]	Memory Game - Road Signs [27]	SmartCop Road Safety Awareness Game.
Offering an overview explanation of traffic signs as feedback.	✓	✗	✗	✗	✓
Tracking elapsed time.	✓	✗	✗	✓	✓
Enhancing memorization skills.	✓	✓	✓	✓	✓
Allowing to review previous attempts and analyze progress.	✓	✗	✗	✓	✓
Maintaining a leaderboard of best players.	✗	✗	✗	✗	✓
Dynamic Difficulty Adjustment in game levels.	✗	✗	✗	✗	✓

Figure 1.5 Comparison with existing systems

1.3. Research Problem

E. K. Adanu and S. Jones [30] discovered that driver error, speeding, distracted driving, fatigue driving, and not wearing a seatbelt are some notable driving behaviors that significantly contributed to the occurrence of serious crashes. They suggest that targeted outreach and training campaigns planned to address these particular behaviors, focusing training efforts on certain driver types and using intensified enforcement would be efficient in decreasing serious crashes. In addition, M. Shawky et al. [29] observed that there is a strong relationship between the accident rate per driver and their previous violation records. In addition, they noticed

that the probability to be affected in an accident significantly enhances with increasing the total number of historical violation records. Thus, as M. Hussin and N. Hanis Mohd Fouzi [1] identified, it is clear that lack of exposure and awareness among communities about traffic environments and rules causes the growth of road accident statistics. Nevertheless, the conventional methods of delivering road safety practices are not very appealing to most people. Besides, other than detecting visible traffic rule violators while patrolling, police officers do not have an overall understanding of public awareness level.

Since generation Z people are addicted more towards digital games, researchers tended to apply game-based learning for instructing road safety. Two fundamental approaches to game development can be found when exploring the related work. The first strategy is quizzes offered in a game context which is a more modest manner to cover a lot of information within the game [9]–[12]. The second procedure is to build a simulated environment, where the player engages in a virtual traffic environment and needs following road safety best practices to earn points [13]-[16]. However, despite the high capacity for interaction being common in Virtual Environments, available game-based solutions to road safety education are currently limited to addressing and evaluating declarative knowledge [5]. Besides, compared to the point-and-shoot type of games, the need for the games which require more 'thinking' for the acquisition of situation awareness has often been pointed out [5].

Therefore, this research intends to develop a mobile game and explore the influences of Game Based Learning on people's attainment and retention of road safety best practices.

While this study aims to provide a practical solution for the above-discussed research problem with the aid of existing knowledge and overcoming above mentioned shortcomings, the derived research questions that are mentioned below will be responded to with the completion of this research.

1. Do critical thinking skills gained through game-based learning more beneficial to learn road safety best practices compared to conventional methods?
2. Do players find the proposed game more engaging and retaining compared to the games that have not used adaptive game difficulty balancing?

3. Do reviewing overall public awareness on road safety through the proposed game's results more beneficial for police officers to get further actions for road accident prevention?

2. OBJECTIVES

2.1. Main Objective

- ❖ To implement a mobile game to enhance public awareness of road accident prevention during the CDAP evaluation cycle using Game-Based Learning and Machine Learning throughout the year.

2.2. Specific Objectives

- To develop a game which is equally impressive for both children and adults.
- To address most of the causing factors for road accidents.
- To design difficulty levels that are suited to individual skill levels.
- To improve users' knowledge retention, decision making, and problem-solving skills.
- To determine the user's awareness level and allow police officers to view overall public awareness.

2.3. User Requirements

- A user shall enhance road accident prevention awareness using the game.
- A user shall view individual awareness progress from user profiles.
- A user shall view the competitiveness using a leaderboard.
- A police officer shall review the overall public awareness using analytical reports.

2.4. Functional Requirements

- The game should be equally impressive for both children and adults.
- It should contain a game instruction tutorial session.
- The game should address most of the road accidents causing factors.

- The game should track elapsed time for a particular level.
- The game should offer an overview of road safety practice as feedback for incorrect attempts.
- The game should maintain a leaderboard of players.
- The game should decide level difficulty dynamically according to the user's skills.

2.5. Non-functional Requirements

- Availability
- Usability
- Performance
- Recoverability

2.6. System Requirements

- Enhance road accident prevention awareness among players using GameBased Learning.
- Allow players to review their awareness progress from user profiles using the previous attempt details.
- Enable users to view the competitiveness using the leaderboard of players.
- Permit police officers to review the overall public awareness from analytical reports generated using players' game scores.

2.7. Expected Outcomes

- Enhance road accident prevention awareness using Game-Based Learning.
- Improve knowledge retention, decision making, and problem-solving skills of the users.
- Enable users to figure out their awareness level and progress through previous attempts.

- Allow police officers to review overall public awareness.

2.8. Potential for Entrepreneurship

- The final product will be a mobile game accessible free through Google Play Store and it shall be used by the public (drivers and pedestrians) and police officers.
- The proposed game will be useful for young drivers seeking licenses or for most drivers to refresh their awareness after they have obtained their drivers' licenses.
- Additionally, this game can be used as a road safety best practices teaching approach to pedestrians and improve their knowledge retention.
- Furthermore, this system will permit police officers to view overall public awareness reports and let them decide whether it is required to conduct training sessions/ seminars, etc. to improve public awareness.

3. METHODOLOGY

3.1. Introduction

The game development process will contain the following stages.

Requirement Gathering and Analysis: A hangman game was chosen as the game type after studying existing systems, reviewing relevant research papers and conducting a survey (Appendix A).

Design and Implementation: According to the gathered information, a hangman mobile game will be designed and developed. The game will use real-time user data (score, elapsed time in a level, etc.) as input parameters to dynamically design the next game level customized to the player's skill level with the aid of Machine Learning.

Testing and Releasing Product: Upon unit testing, integration testing, and system testing, the game will go through User Acceptance Testing (UAT). If the system will not be able to get UAT approved, it may have to redo the previous flow of events and continue to do modifications until the game gets UAT approved. Upon approval, the product will be released and will be available for the public freely accessible through the Google Play Store.

3.2. Requirement Gathering and Analysis

Initially, the requirement of the application and the main features that should be covered was identified and discussed with the officers at Nugegoda, Mirihana Police Station, Sri Lanka.

Then, a hangman game was chosen as the game type after studying existing systems, reviewing relevant research papers and conducting a survey (Appendix A).

3.3. Design and Implementation

Initially, the hangman flutter mobile application was developed with static next level question retrieval feature from the cloud firestore database. Thereafter, the administrative functionalities and the signup, login functionalities were developed. Then, a Support Vector Machine Binary Classification Machine Learning model was implemented and trained using a dataset obtained from Kaggle [33]. A 3rd party accessible API was developed using this SVM model and used through mobile application inorder to predict the difficulty level of a given word. Besides, another Logistic Regression Multi Class Classification Machine Learning model was developed and trained using a dataset (score and elapsed time) obtained from the users who have played the initial static level based mobile game. Another 3rd party accessible API was implemented using Flask and used in the Flutter application inorder to predict the user-specific difficulty level of a given word. Then, the mobile application was re-designed to retrieve the next level question difficulty level dynamically according to the predicted user-specific question difficulty level. Figure 3.1 depicts the overview of the implemented solution.

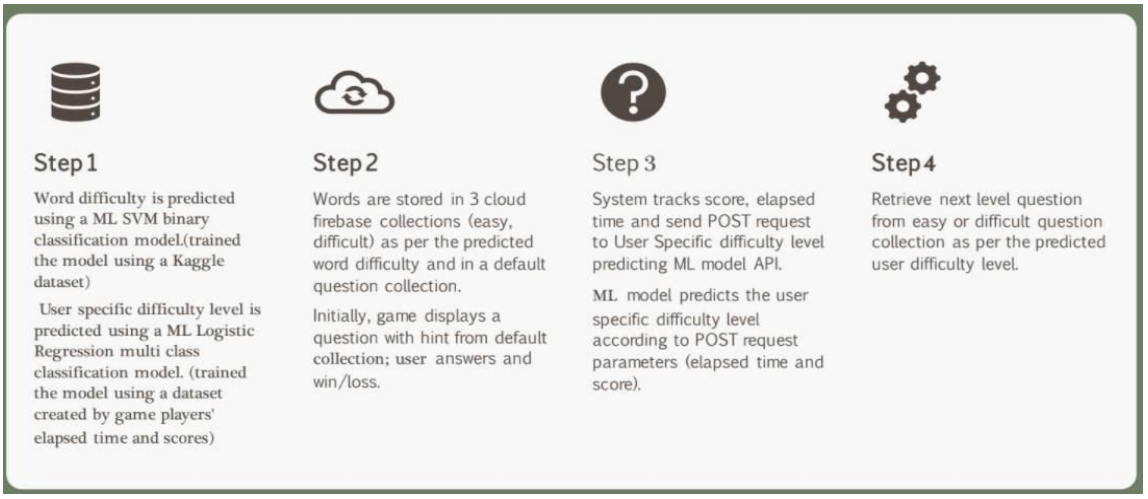


Figure 3.1: System Overview

3.4. The Flow of the System and System Functionality

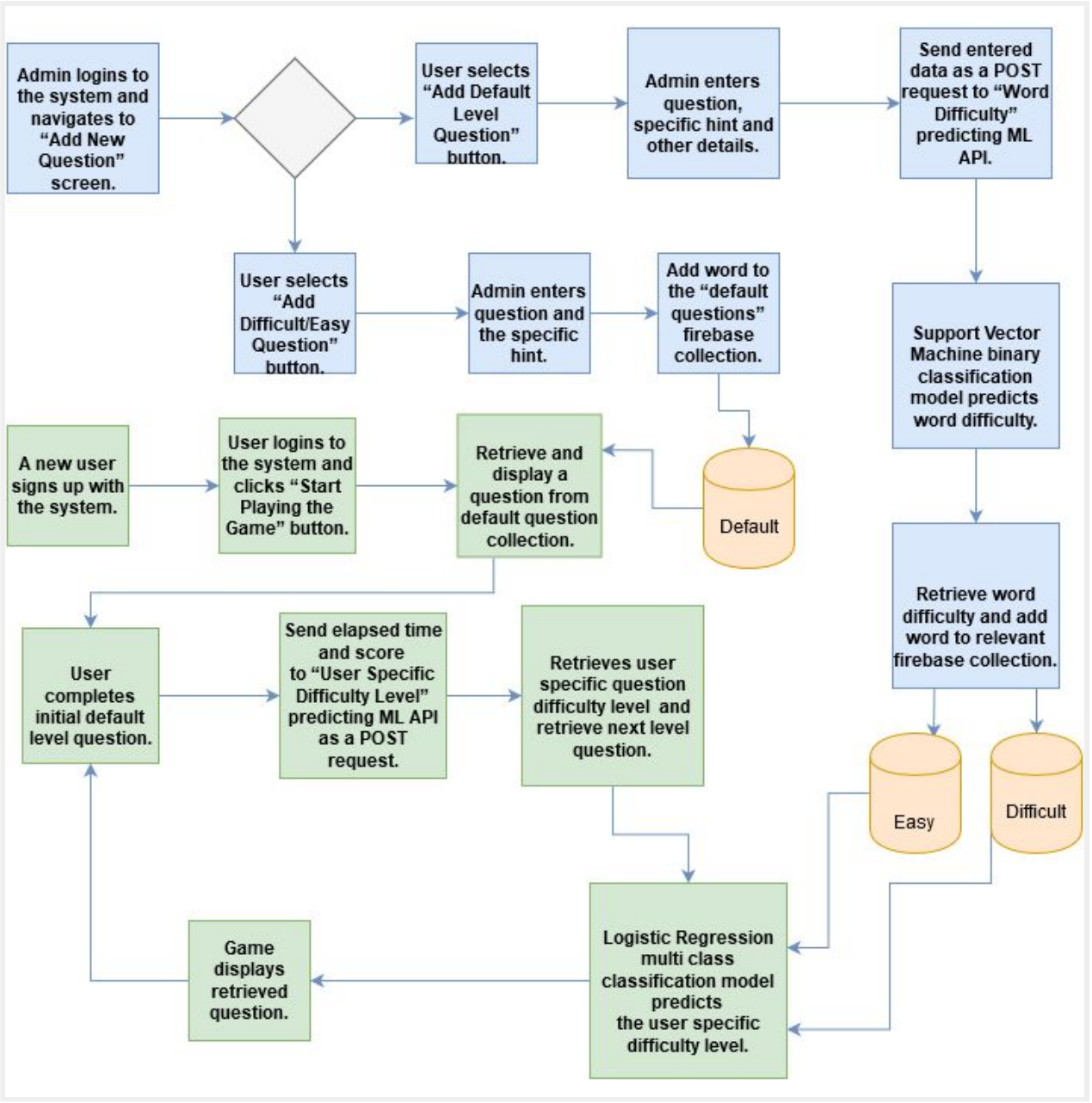
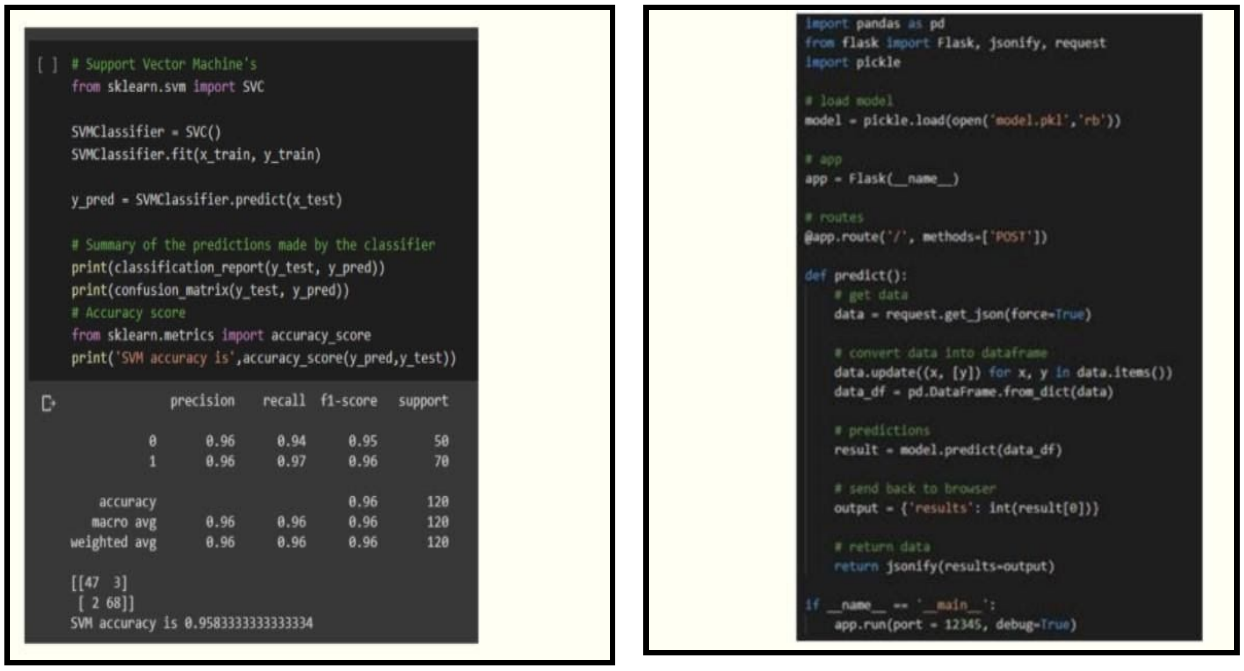


Figure 3.2: Flow of the System

The “SmartCop - Road Accident Prevention Game” has been developed to improve the public awareness about road safety best practices in a more innovative and appealing approach. The game addresses not only the knowledge of traffic rules, but also the knowledge of causes for road accidents, such as driving behavior, violations, crashes, vehicle handling talents, on-road driver practices, etc. Since most of the currently available educational solutions are quizzes and are limited to assessing declarative knowledge as per the literature review, ultimately, the second highest preference of the conducted survey; a “Hangman Game” was decided to be developed in order to deliver and assess procedural knowledge, enhance people’s problem solving skills while achieving more user engagement. Furthermore, compared to Multiple Choice Questions; the proposed puzzle-like Hangman game improves users' knowledge retention, decision making, and problem-solving skills [32].



```
[ ] # Support Vector Machine's
    from sklearn.svm import SVC

    SVMClassifier = SVC()
    SVMClassifier.fit(x_train, y_train)

    y_pred = SVMClassifier.predict(x_test)

    # Summary of the predictions made by the classifier
    print(classification_report(y_test, y_pred))
    print(confusion_matrix(y_test, y_pred))
    # Accuracy score
    from sklearn.metrics import accuracy_score
    print('SVM accuracy is',accuracy_score(y_pred,y_test))
```

```
              precision    recall  f1-score   support

           0       0.96      0.94      0.95        50
           1       0.96      0.97      0.96        70

    accuracy                           0.96       120
   macro avg       0.96      0.96      0.96       120
weighted avg       0.96      0.96      0.96       120

[[47  3]
 [ 2 68]]
SVM accuracy is 0.9583333333333334
```

```
import pandas as pd
from flask import Flask, jsonify, request
import pickle

# load model
model = pickle.load(open('model.pkl','rb'))

# app
app = Flask(__name__)

# routes
@app.route('/', methods=['POST'])

def predict():
    # get data
    data = request.get_json(force=True)

    # convert data into dataframe
    data.update((x, [y]) for x, y in data.items())
    data_df = pd.DataFrame.from_dict(data)

    # predictions
    result = model.predict(data_df)

    # send back to browser
    output = {'results': int(result[0])}

    # return data
    return jsonify(results=output)

if __name__ == '__main__':
    app.run(port = 12345, debug=True)
```

Figure 3.3: Implementation of Machine Learning and Flask APIs

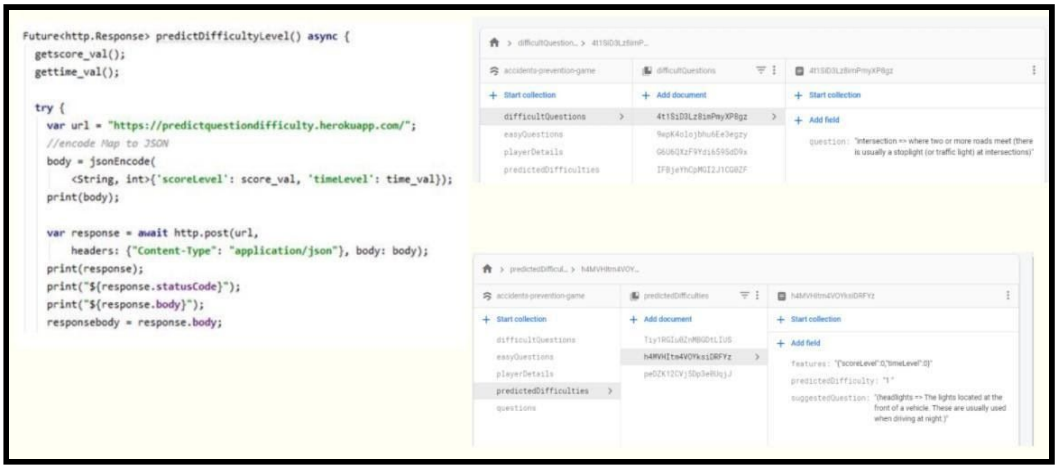


Figure 3.4: Calling Flask POST API from Flutter Application

The game is developed using Flutter, Dart programming language, and Firebase database. As per Figure 3.5, the developed application follows 6 cognitive levels of Bloom's Taxonomy.

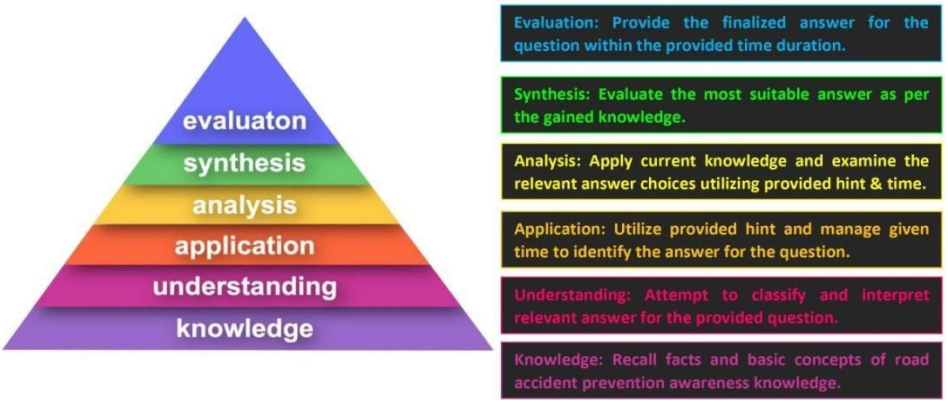


Figure 3.5: The 6 cognitive levels of Bloom's Taxonomy.

As Figure 3.2 depicts, the game development process will contain the following stages. Pre-registered users with administrative privileges can add new words to the game. Admins can select either the “Add Default Level Question” or “Add Difficult/Easy Level Question” option. Then, the administrator will be redirected to

the relevant data entry screen. There, users will be able to insert the required data for predicting the word difficulty level. Here, the User Interface of the Flutter Application takes the user inputs and sends them to the implemented Flask Machine Learning Model API as a POST request. This Machine Learning Model is a Support Vector Machine Binary Classification Model and it has been trained using a dataset available at Kaggle [33]. Word difficulty is predicted as per the indicators mentioned below and the word is then added to the relevant firebase question collection (easy/difficult) as per the predicted word difficulty level.

Character count / Word Length: Maximum the number of characters found in the word, Word is difficult

Syllable Count: More the number of syllables count more will be the chance of word to be considered as difficult.

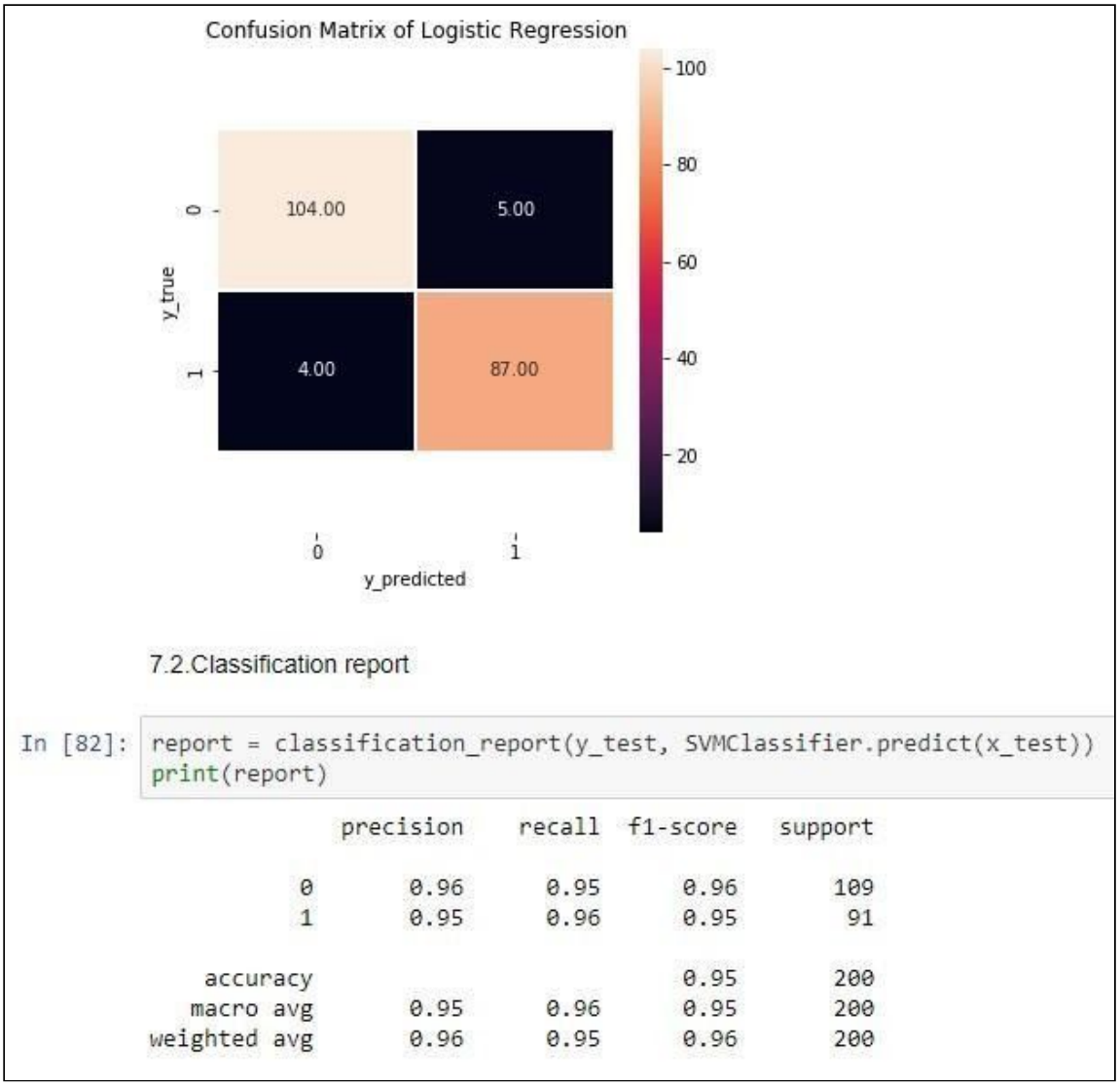
Part of Speech Tags: Nouns are easier to learn as compared to verbs and adjectives; whereas adverbs are difficult as they describe the abstract idea.

Presence of ch/st/th/f/sh in words: Ch /st/th/f/sh produce high-frequency sounds during pronunciation and are considered as high-frequency letters. So their presence makes the word difficult to understand.

Presence of C or K in words: Sometimes the pronunciation of c and k are the same or different in context. So it is difficult for the child to recognize what to read.

Presence of G or J in words: Sometimes pronunciation of g and j are the same or different in context. So it is difficult for the child to recognize what to read.

Frequency of occurrence: If a word appears more frequently, then the word is easy otherwise difficult.



7.2.Classification report

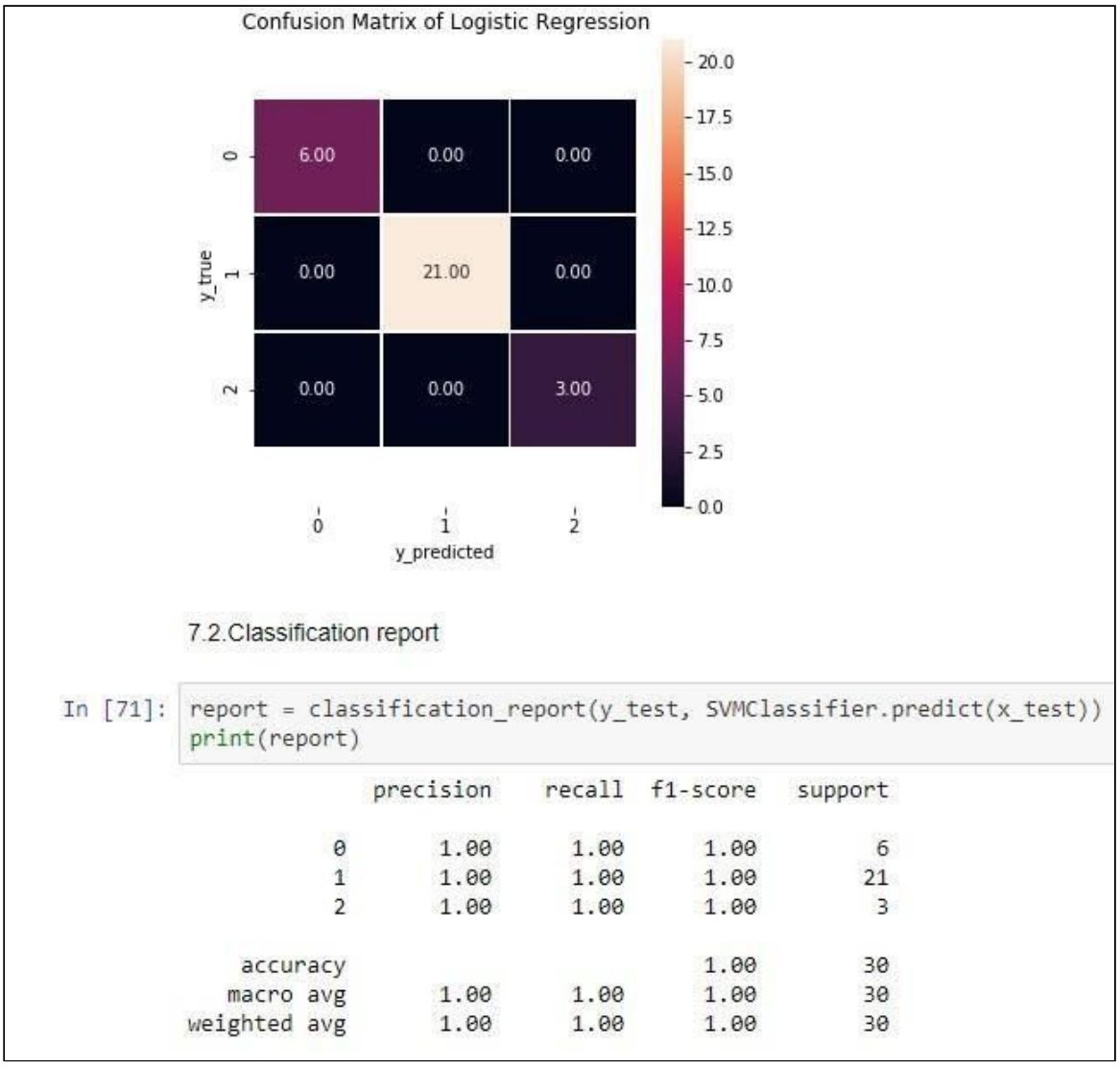
```
In [82]: report = classification_report(y_test, SVMClassifier.predict(x_test))
         print(report)
```

```
              precision    recall  f1-score   support

           0       0.96      0.95      0.96       109
           1       0.95      0.96      0.95        91

    accuracy                           0.95       200
   macro avg       0.95      0.96      0.95       200
weighted avg       0.96      0.95      0.96       200
```

Figure 3.6: Confusion Matrix and the Classification Report of SVM Classifier



7.2.Classification report

```
In [71]: report = classification_report(y_test, SVMClassifier.predict(x_test))
         print(report)
```

	precision	recall	f1-score	support
0	1.00	1.00	1.00	6
1	1.00	1.00	1.00	21
2	1.00	1.00	1.00	3
accuracy			1.00	30
macro avg	1.00	1.00	1.00	30
weighted avg	1.00	1.00	1.00	30

Figure 3.7: Confusion Matrix and the Classification Report of Logistic Regression Classifier

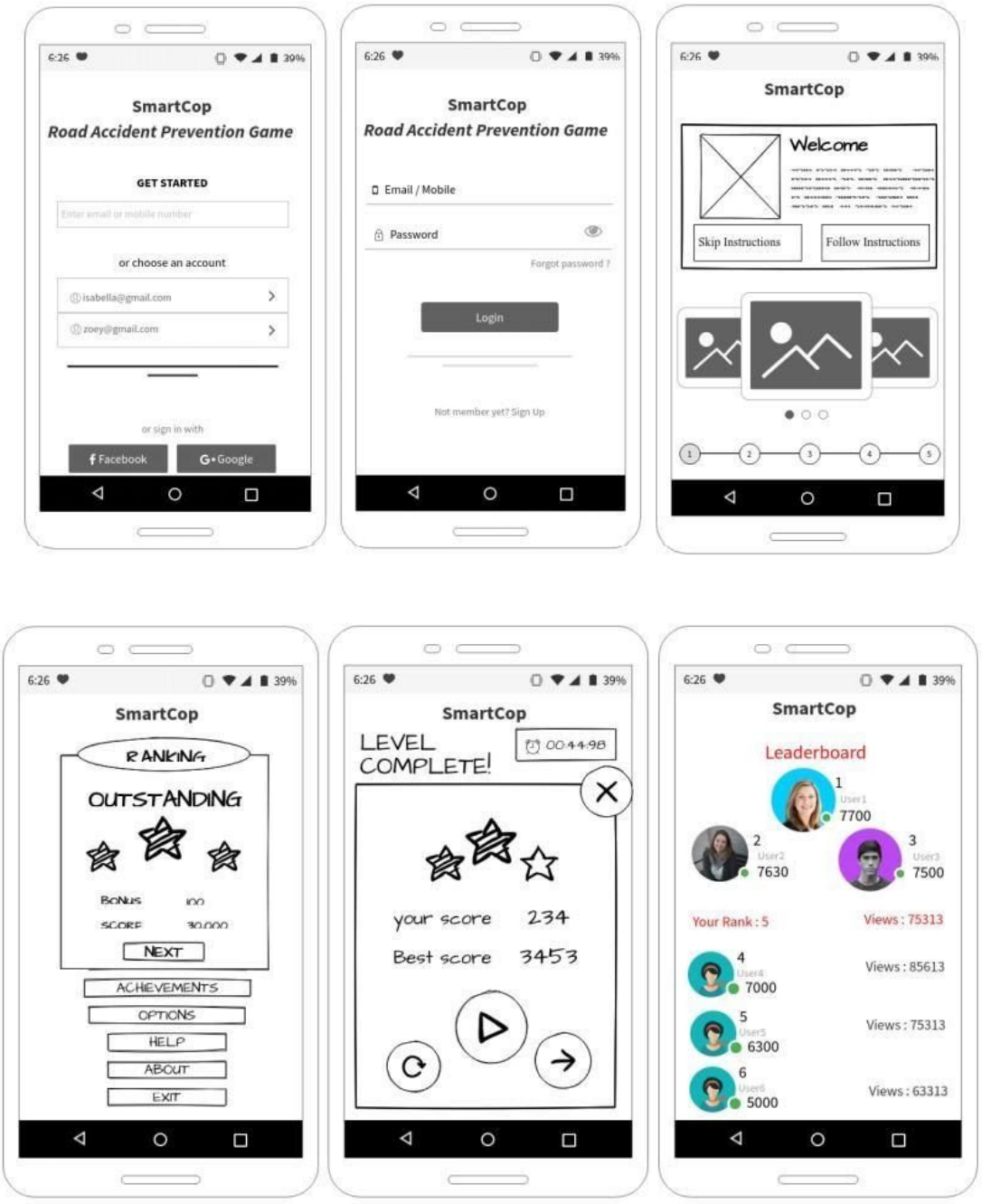


Figure 3.8: Wireframes drawn for the SmartCop Accident Prevention Game

Users need to sign up/register with the system and login to the application prior to playing the game. The implemented game is a hangman word game, where a user

will initially receive a default level question with a hint, 60 seconds to answer, and a default max score of 10. For each incorrect guess, 1 mark is deducted, and the player gets only 7 attempts to tryout filling the blanks and finding the hidden word without losing the game level. Figure 3.9 shows user interfaces of the implemented hangman mobile game. Upon completion of the initial default level, the system tracks the score and the elapsed time for the user to complete the default question, and then predicts the user-specific difficulty level for the next question. For the prediction, a pre-trained Machine Learning Logistic Regression multiclass classification model is used. This model is trained with the use of data (obtained score and the elapsed time) collected from the users who have played this game.

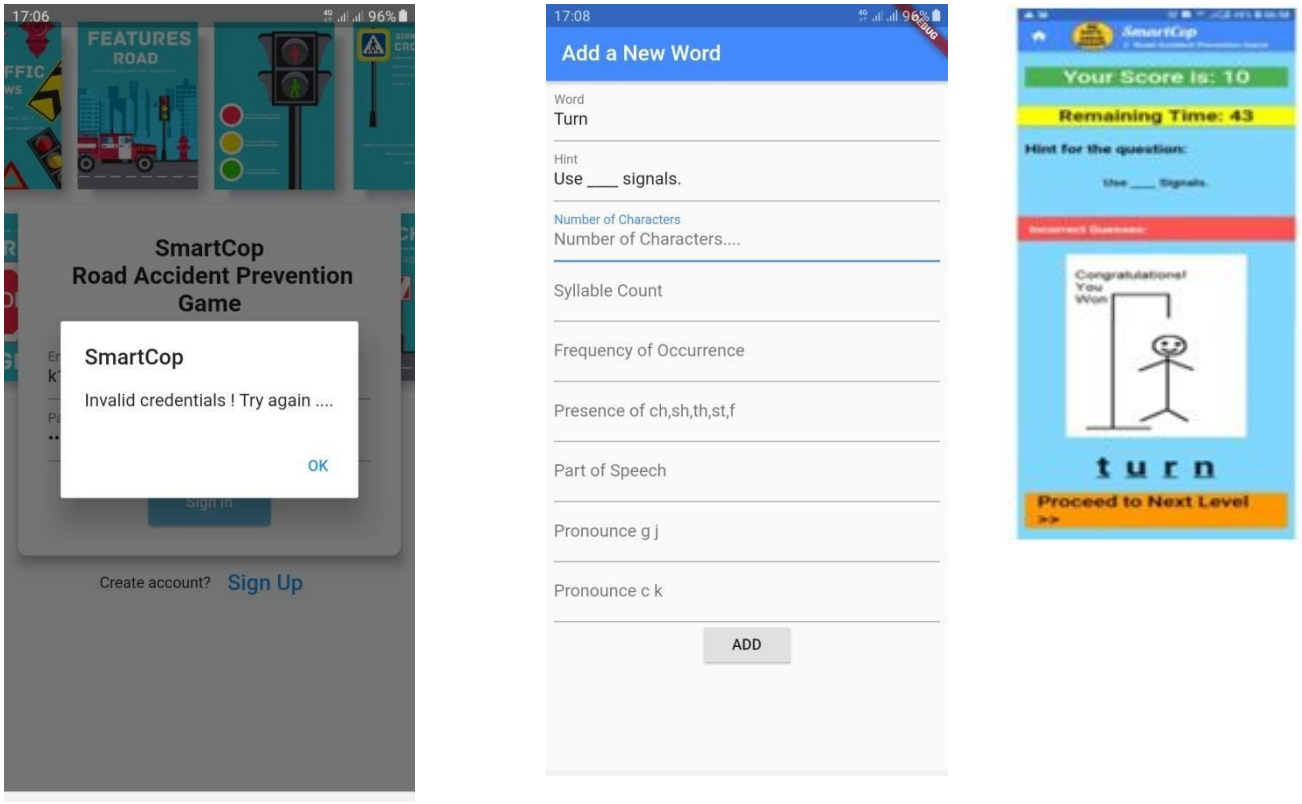


Figure 3.9: User Interfaces of SmartCop Accident Prevention Game

Then, the next level question is taken from the database where there are 3 collections, categorized as default, easy, and difficult. Upon retrieving the predicted

user-specific difficulty level, the system dynamically retrieves an appropriate next level question from the easy/difficult question collection, aligning with the predicted user-specific difficulty level. This process is repeated, producing a new level of the game dynamically, that suits the individual player's performance in the previous level.

Depending on each game attempt detail (score, elapsed time, user-specific difficulty levels for each question, etc.) and player's progress throughout the levels, the awareness of road accident prevention of the player is measured. As depicted by results and discussion section, it is obvious that Game Based Learning will be a promising approach for sharpening road accident prevention awareness among the community and it proves that the implemented hangman game assists to reduce accident rates by improving users' road accidents prevention awareness knowledge gradually along with increasing number of game play attempts.

3.5. Tools and Technologies

- IDE – Android Studio

  Android studio IDE has been used for both frontend and backend development of this mobile application.

- Programming language - Flutter with Dart programming language

  Flutter has been used to implement this application since it supports both Android and IOS with a single code base. Furthermore, it supports hot reload, expressive and flexible user interface animation, and single language for backend and layout.

- Database – Firebase

  Firebase has been used for user authentication and to store and sync all the other required data in realtime.

- Machine Learning Model - Python Programming language using Anaconda Navigator and Jupyter Notebook

Jupyter Notebook, that is available in Anaconda Navigator desktop GUI has been used to implement the machine learning model.

- Machine Learning API – Flask and Heroku

  Flask has been used as a backend for API to connect a machine learning model with a mobile application.

  Heroku, which is a well known Platform as a Service (PaaS) has been used to manage, deploy and scale this application.

3.6. Testing and Releasing Product

3.6.1. Frontend test cases

Table 3.1: Front end test results and how system tests

Test Case ID	Test Scenario	Test Steps	Test Data	Expected Results
T001	Verify whether the letter key disables after the player provides a guess	1. User Launch the game. 2. Login with valid credentials. 3. Player starts to play the game. 4. Player press on a letter key.	1. User login credentials. 2. Guessed letter	The pressed letter key should be disabled and will not consider throughout the level again.
T002	Verify whether the game identifies a failed attempt	1. User Launch the game. 2. Login with	1. User login credentials. 2. Guessed letter	The game identifies a fail attempt and deducts

	after a player provides an unsuccessful guess (word do not contain the letter).	valid credentials. 3. Player starts to play the game. 4. Player press on a letter key	(unsuccessful attempt).	score.
T003	Verify whether all the blanks that contains the letter key fills after player providing a successful guess.	1. User Launch the game. 2. Login with valid credentials. 3. Player starts to play the game. 4. Player press on a letter key.	1. User login credentials. 2. Guessed letter (successful attempt).	The game identifies a correct attempt fills the relevant blanks.
T004	Verify whether the next question appears after the player successfully filling all the missing spellings.	1. User Launch the game. 2. Login with valid credentials. 3. Player starts to play the game. 4. Player press	1. User login credentials. 2. Successfully guessed a set of letters.	Game will display “Congratulatio n ons!”, stops the countdown timer and enables the “Proceed to the next

		on a letter key.		question" button.

3.6.2. backend test cases

Table 3.2: Backend test results and how system tests

Test Case ID	Test Scenario	Test Steps	Test Data	Expected Results
T005	Test whether the email and marks that the user has gained is stored in the firebase collection.	1. User Launch the game. 2. Login with valid credentials. 3. Player starts to play the game. 4. Player completes playing the game.	1. User login credentials. 2. Marks obtained by the user.	User's email and the obtained score should be stored in the relevant firebase collection.
T006	Verify whether ML model predicts user specific difficulty level for each question.	1. User Launch the game. 2. Login with valid credentials. 3. Player starts to play the game. 4. Player completes one level. 5. Mobile app tracks the obtained score and the elapsed time for the user to	1. User login credentials. 2. Score and the elapsed time for a particular question completion.	Mobile application sends tracked score and elapsed time as a POST request to the Flask API, ML model predicts the user specific difficulty level for the particular question, mobile app obtains a suitable next level question

		complete the question. 6. Mobile app sends score and time levels as a POST request to the Flask API. 7. ML model predicts the user specific difficulty level for the particular question and obtains a suitable next level question from the relevant firebase collection.		from the relevant firebase collection.

The product will be released and will be available for the public freely accessible through the Google Play Store.

4. RESULTS AND DISCUSSION

The main expected outcome of our proposed game-based awareness modules is to improve road safety awareness, decision making, reacting speed and critical thinking ability of the public. In the initial stage of performance evaluation, both "SmartCop - Road Accident Prevention Game" was given to a set of randomly selected people including 5 students and 5 teenagers who have suffered from road accidents recently. They were asked to attempt the game three times and we recorded their performances for all attempts and then compared their improvements from attempt number 1 to attempt number 3.

Table 4.1: Results for the students

Attempt	Marks				
	S1	S2	S3	S4	S5
1	60	50	63	71	30
2	68	65	77	83	50
3	74	80	82	92	60

Table 4.2: Results 5 teenagers who have suffered from road accidents recently

Attempt	Marks				
	Y1	Y2	Y3	Y4	Y5
1	65	70	50	49	38
2	70	83	61	55	47
3	78	92	70	63	63

The test results shown in Table I to Table II, display an improvement in the scores of the players, when they re-try the activities. Also, there is an improvement of the scores through attempt 1 to attempt 3.

CONCLUSIONS AND RECOMMENDATIONS

In this component, I have proposed to enhance road accidents prevention awareness using a game-based learning approach. I have used supervised learning techniques and game-based learning approaches to implement the above-mentioned module. I have conducted the initial evaluations to check the performance of the implemented game, and it showed that the expected skills of the people are improved, and through that awareness among the public is improved.

As future work, I am planning to enhance this game with more effective techniques to attract players. Also, I am planning to evaluate the performances of the game comprehensively using a large set of players.

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APPENDICES

APPENDIX – A: Survey Questions

SmartCop Road Accident Prevention Game

We expect to develop a mobile game to enhance public awareness of road accident prevention. Your responses will be used to identify the most preferred game genre among people for refreshing knowledge of traffic rules and road safety ethics. Thank you very much for taking the time to complete this survey and your participation is highly appreciated.

* Required

Background and Demographics

1. What is your age? *

- ◯ Bellow 10 years
- ◯ 11 to 18 years
- ◯ 19 to 30 years
- ◯ 31 to 45 years
- ◯ 46 to 59 years
- ◯ Above 60 years

2. Are you a *

- ◯ Male
- ◯ Female

3. What is your current employment status? *

- ◯ Full-time employment
- ◯ Part-time employment
- ◯ Unemployed
- ◯ Student
- ◯ Retired

4. Do you have a driving license? *

- ◯ Yes
- ◯ NO

5. Do you find it easy to learn and remember traffic rules and road safety ethics using conventional methods like reading books/attending seminars? *

- ◯ No
- ◯ Yes

6. Do you think that it will be easier to learn and remember traffic rules and road safety ethics by playing a mobile game? *

- ◯ No
- ◯ Yes

7. If yes, which of the following game types that you think would be more effective to learn and remember traffic rules and road safety ethics? *

◯ Crossword

◯ Word Search

◯ Word Sudoku

◯ Hangman Game

◯ Trivia Quiz

8. What is the reason for your choice in 7th question? *

Your answer

9. What are your main difficulties when playing digital games? *

- [ ] Difficult to see or hear
- [ ] Too complicated
- [ ] Privacy concerns
- [ ] Difficult to use the controller
- [ ] Limited or no access to technology
- [ ] Other:

10. In your option, has playing digital games increased or decreased the following: *

	Increased	No deference	Decreased
Focusing attention	○	○	○
Memory	○	○	○
Reasoning	○	○	○
Problem solving	○	○	○
Speed in responding	○	○	○

Thank you very much for taking the time to complete this survey.

Submit

Page 1 of 1

Never submit passwords through Google Forms.

APPENDIX – B: Questionnaire for Testing Road Accident Prevention Awareness Knowledge Progress from the implemented Hangman Game.

Fill in the blanks. Number of letters in the word is mentioned inside brackets.

Time: 20 minutes. Marks: 10.

1) Don't _ _ _ _ _ & drive. (5)

2) Stick to the _ _ _ _ _ limit. (5)

3) Put the _ _ _ _ _ away. (5)

4) Wear your seat _ _ _ _. (4)

5) Take _ _ _ _ _ passengers. (5)

6) Check your _ _ _ _ _ spot every time. (5)

7) Turn on your _ _ _ _ _ _ _ _ _ _. (10)

8) Follow traffic _ _ _ _ _ _ _. (5)

9) Don't drive if you are _ _ _ _ _ _. (6)

10) Use _ _ _ _ signals. (4)