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Bullet Id: A Virtual Bullet Identification for Forensic Ballistics Students

Geraldo P. Roxas [1], Robino D. Cawi [2]

[1] PhD Student, College of Criminal Justice Education, University of the Cordilleras
[2] Dean, College of Criminal Justice Education, University of the Cordilleras

Abstract

As school is a public place where crowd is unavoidable and children are vulnerable, there is a need to strengthen policy in terms of the delivery of instruction - to provide opportunities for online learning platforms. Numerous innovative programs have been proposed by the different learning sectors in the Philippines. The Commission on Higher Education suggested to strengthen online platforms and blended learning such as but not limited to google classroom, messenger, zoom, Edmodo, Facebook and YouTube.

This study was conducted using the Agile Software Development Methodology. The Bullet ID is a promising educational tool that will help both the instructors and students in their learning activities specially in the field of forensic ballistics. This new learning technology will bridge the gap between face-to-face and online classes.

The main feature of this system is that it is an offline-based mobile application which made it different from the other forensic ballistic application developed by other researchers which are computer-based software application that requires internet connection.

Keywords: Bullet, Identification, System, Mobile, Application

1. Introduction

The COVID-19 pandemic has caused the largest disruption in human history, and to education systems, affecting nearly 1.6 billion students in more than 200 countries. The closure of schools, educational institutions and other schools affected more than more than 9 percent of the world's students. It has brought vast changes in all aspects of our lives. Social distancing and policies restricting movement significantly disrupted, traditional educational practices. Reopening schools after easing restrictions is another challenge, as many new standard procedures have been implemented.

In Bhutan, lockdown and closure of schools was first announced in the second week of March 2020 (Kuensel, 2020, March 6). A total nationwide lockdown is in place from August 1, 2020 (Palden, 2020). Meanwhile, movements have been allowed, offices have begun to operate, schools and colleges have reopened for certain levels, and continued with online courses for those who need it. More than 170,000 children in Bhutan in grades PP-XII are, affected by the closure of schools. The impact is significant and has impacted learning. Some schools, colleges and universities have stopped teaching face-to-face.

During the short period of the COVID-19 pandemic, many researchers shared their teaching and learning efforts in different ways. Several schools, colleges and universities ended face-to-face teaching. are afraid of losing the academic year 2020 or even more in the near future. The need for class is to innovate and implement alternative education systems and assessment strategies. The COVID-19 pandemic has given of us the opportunity to pave the way for the adoption of digital learning.
For India and the UK, the impact of COVID-19 in education was significant and proved a challenge, particularly for subjects which rely heavily on practical or hands-on learning sessions. It was clearly argued why higher education should continue and so significant effort was placed on urgently resolving this issue while providing a meaningful education experience for students. For most, this meant concluding that some form of online education system was the only solution in order to ensure that all students continued to have access to the curriculum (Sahi, 2020).

In the study of Krishnamurthy (2022), he stated that a significant consequence of the pandemic in higher education has been the switch to an online mode of teaching. This work highlights the various strategies adopted to teach an online introductory forensic science course. A combination of methods including live synchronous classes, asynchronous pre-recorded videos followed by active discussion in class, usage of Canvas as a learning management system, continuous assessment with individual and group activities were adopted as strategies to teach this online course. He found out that students felt that the learning resources (such as live recording of classes and pre-recorded videos), interactive polls, chats, discussion forums, group projects and presentations helped them as they navigated through the online course. Furthermore, students also felt that online quizzes on Canvas and remotely proctored exams were effective in testing their knowledge and understanding of the subject. Overall, students enjoyed the forensic case study discussions, the interactive style of teaching and the various pedagogical strategies employed in the course.

In addition, Kimberlee Moran, in her eight years of teaching forensic science at Rutgers University-Camden, never had a class with perfect attendance and student participation however, Coronavirus changed that. After she spent 150 hours over the summer overhauling the online curriculum for one of her courses—Forensic Science Theory and Policy—following a weeklong workshop offered by the Office of Instructional Design and Technology (IDT), she saw the results in her classes (Rutgers University, 2020). Based on the pointers she received from IDT, Moran, an associate teaching professor and director of forensics with the Department of Chemistry at Rutgers-Camden, flipped the way she teaches. Her students review updated material on their own and attend weekly one-hour synchronous video discussions to build on those lessons. She found a workaround to large weekly lab activities that are part of her Forensic Patterns Evidence course, which focuses on what she calls “cop science”—assessing fingerprints, footprints, tire prints, ballistics, and blood spatter—by taking advantage of a closet-sized space in the Science Building. Students who live within driving distance of campus schedule weekly solo lab time to work on their assignments in a socially distanced way. Moran also realized that virtual learning offers her new teaching opportunities and more accessibility for the first-time despite of the fact that at first, Moran saw the all-virtual format as a challenge, but now she realizes it adds new possibilities to how she can teach when she takes a new approach.

However, in other countries like India, Sumitra (2021), highlights a number of shortcomings such as weak online teaching infrastructure, teachers' limited exposure to online teaching, lack of information, unfavorable environment for online learning at home, public degree and academic excellence in terms of higher education.

In terms of delivering course material, universities were required to devise solutions for three typical types of session: the traditional styled lecture, seminars, and practical sessions. Arguably lecture delivery offered the fewest issues, where online video conferencing platforms designed for such activities exist. A combination of live and asynchronous pre-recorded approaches provided flexibility for students, taking into account the pressures created by the pandemic, 'key worker' statuses and volunteering initiatives, meaning that it is not viable to expect students to attend online sessions at set times. While pre-recording content carries an up-front cost, the benefit of having a static, replay-able resource for students to digest in their own time and capacity is seen as of-value. Of course, many lecturers and students alike seek to encourage positive interaction in their lecturing sessions, and indeed such approaches have long since been seen as of benefit to students and their learning. As a result, many institutes will have supplemented recordings with shorter, live question and answer styled sessions to confirm understanding, address any confusion and possibly of most importance, to see their students, check on well-being and simply talk to them. It is important that following the imposed lockdown, academics do no simply disappear from interacting in real time with students, and technology offers a stop-gap solution at this time. (Hackathorn et al., 2012)

Seminar and practical sessions provide somewhat of a challenge. At the crux of their value lies the ability for students to consolidate knowledge by 'doing' and 'using' the knowledge they have acquired. Work by Erana-Rojas et al. (2019) noted that 89% of their students found that practical session broadened their perspective of forensic sciences and 93% understood forensic processes better. Particularly in the context of forensic science and all its sub-disciplines, students need to apply best practices, seek evaluation of their performance and understand the context of any techniques by using them. Furthermore, practical sessions develop the necessary psychomotor skills required in many aspects of forensic analysis. Basic wet laboratory skills such as weighing, pipetting, and microscope slide making, along with DNA swabbing and fingerprint recovery techniques, for example, are important in many aspects of forensic science. Yet often, forensic science equipment must stay within its lab environment due to health and safety, immobility, expense and licensing issues meaning that the lab cannot be 'brought to the student at home'. Regardless of the method and platform, universities and their academics are encouraged to maintain communication with their students. What would once have been face-to-face, a knock at the office door or a two-minute post-lecture chat, has turned into a computational request for communication. This has the potential to have opposing effects and likely depends on the student in question. Furthermore, the lack of immediate response could encourage an exercise of research skills fostering a more independent approach. On the other hand, what is lacking is the connection and to some extent the opportunity for organic discussions around the questions. The type of student here is important, those that favor independent research will likely thrive, while those that benefit from interaction and talking things through to process ideas and knowledge may find themselves out of their comfort zone or, worse, left behind. Additionally, those once visible indicators of students in need of both study and well-being support are no longer there, meaning that it is vital that they continue to be available in order to identify and address any

warning signs. Flexibility is key here, ensuring students have multiple opportunities to seek support which in some cases means non-traditional hours-for-contact.

Forensic education in India was largely delivered via the Zoom and Webex applications following instructions and training given to faculty and students. Over time and with continued use of the application, teachers and learners became accustomed to this virtual approach. Regular lectures were arranged using this application for all the learning hours. For Indian students, the most important advantage of this approach was the fact that lectures could occur in real-time, keeping the students engaged in educational activities and completion of the curriculum as per the schedule. The disadvantages varied from place to place, but included: being unable to confirm the student's attendance, difficulties in achieving active engagement of students, internet connectivity issues, deliberate or inadvertent disturbances such as unnecessary voices and annotations over the display screen, and there were a few students who were deprived of the education resource materials. Few universities developed and offered learning cellphone application with 3D technology to medical students. Videos generated prior to the pandemic depicting faculty performing and explaining such things as autopsies emphasized important findings and were shared with the students in a way which maintained confidentiality yet initiated interactions and discussion. Institutional support was also extended to support increased subscription to various e-learning modules, e-books, e-library access, additional international journals, etc. to provide the students with multiple new learning modalities in their homes. Understanding mental stress under lockdown and curfew mentorship sessions were arranged on regular interval and individual basis (Wenjun et al., 2020).

As in India, UK forensic courses adopted a range of online tools to support students up to, and into, the examination period. These included Microsoft Teams, Webex, Zoom, as well as Blackboard Collaborate and Padlet. WhatsApp, Facebook and similar social media apps were used significantly less by comparison.

The live delivery of seminars still occurred alongside a blended approach of prerecorded or written content, seminar tutor delivery, time for independent student work, and facilitated group discussions. For example, students were asked to watch a video demonstrating a forensic technique posted on the virtual learning platform or read a document such as a court statement ahead of the live seminar session. Some theoretical content was discussed by the seminar tutors, then the students were assigned a task to work on independently for a short period of time. The session was then resumed and students would be asked to share their work via the chat box of the platform used, or to share their screen with other members of the seminar class, and a facilitated group discussion took place. This broke up the time spent in the online session, encouraged engagement with the learning, and enabled fruitful group discussion.
In the Philippines, educational leaders decided to adopt the new normal in education. At the basic education, the Department of Education (DepEd) implemented the Learning Continuity Plan (LCP), which was in effect School Year 2020-2021 and classes opened on August 24, 2020 instead of June 2020 (DepEd, 2020). In the higher education sector, the Commission on Higher Education, HEIs were given academic freedom and should implement available distance learning, e-learning, and other alternative modes of delivery to students (CHED, 2020). Several universities have opted to implement their own policies regarding instruction and opening of classes starting August 2020. It will be the new normal in education

and strengthening educational planning and health is a concern to provide quality, inclusive and accessible education for every student.

As school is a public place where crowd is unavoidable and children are vulnerable, there is a need to strengthen policy in terms of the delivery of instruction - to provide opportunities for online learning platforms. Numerous innovative programs have been proposed by the different learning sectors in the Philippines. The Commission on Higher Education suggested to strengthen online platforms and blended learning such as but not limited to google classroom, messenger, zoom, Edmodo, Facebook and YouTube (CHED, 2020). In addition, schools will adopt numerous learning delivery options such as but not limited to face-to-face, blended learnings, distance learnings, and home-schooling and other modes of delivery (CHED, 2020; DepEd, 2020).

However, the implementation posed such problems on students who have limited internet access, no gadgets and the poor. According to the report of Akamai (2017), the Philippines has the lowest internet connectivity in Asia. Besides, such challenges would be equity gaps, students' security and safety, quality of learning compromised and poor assessment results (Winthrop, 2020). Changes on the grading system, assessment and evaluation of student's performance will also be a challenge to every administrator.
In addition, laboratory activities in sciences and other subjects that require performance such as Forensic Science in criminology education would be limited to paper and pen test, unless schools will require students to be physically present to be assessed through performance tests. In terms of teaching, teacher training to online instruction, blended learning and distance learning is also recommended in order to adjust to the new instructional format (Toquero, 2020). Teacher competencies in both pedagogy and technology should be reinforced. This transition to the new normal, from the four corners of the classroom to the borders of virtual reality, every learning institution needs to study how successful online learning is in providing quality education and outcomes-based education to students (Basilaia & Kvavadze, 2020).
In addition, forensic science educators have long argued for the use of more innovative approaches in forensic teaching. The lockdown has forced individuals and departments to embrace these views with speed. In the post-pandemic world, another transition will be expected as people move to a hybrid learning framework with physical distancing.

For example, the University of the Cordilleras Innovation and Nurturing Space (UCIANS)Technology and Business Incubator in Baguio City has initiated several projects to help the criminology education in the country in advancing their teaching and learning experience through innovative technological projects. In a statement, Dr. Ariel Pumecha (2020), stated that the UCIANS is a Technology Business Incubator funded by the Department of Science and Technology (DOST) through the Higher Education Readiness for Innovation and Technopreneurship (HEIRIT) project. The objective of the center is "To drive the culture of innovation by providing business and technology transfer opportunities among faculty, students, alumni and community".

The UCIANS has for its banner program IT in Criminal Justice and Public Safety. Hence, the center focuses in projects related to information technology in the field of criminal justice and public safety.

In this regard, the UCIANS hosted a hackathon on February 2021 with the theme "Hack for Justice". The event aims to bring together brilliant ideas to solve existing problems related to criminal justice and public safety.

On the other hand, the researcher asked his students and co-faculty members in criminology about their online learning experience specially in the field of forensic science. He found out that students and instructors are hindered to experience hands-on teaching and learning experience because of the pandemic and lack of laboratory equipment.

In light of the foregoing reasons, the researcher decided to conduct a study in order to design and develop the Bullet ID system for forensic ballistics students and educators.
The main feature of this system is that it is an offline-based mobile application which made it different from the other forensic ballistic application developed by other researchers which are computer-based software application that requires internet connection.

The fact that this system is on offline-based mobile application, students with no laptop and those who have poor internet connection in their areas will be able to experience this innovation in the field of forensic ballistics subject.

Same with the Integrated Ballistics Identification System (IBIS), the Bullet ID is only limited and capable to perform cross matching based on the stored database. That is why, if the fired bullet is not registered in the database, the need for a manual matching is an option.
Therefore, this new teaching and learning experience for criminology instructors and students will address the problems of distant learning and lack of laboratory equipment. Thus, even face-to-face classes will soon be 100% fully implemented, and/or a new pandemic will strike in the future, this mobile app will still be usable in teaching and learning forensic ballistics subject.

Theoretical/Conceptual Framework
The education necessary for life cannot be provided through traditional methods. People need to learn more effectively when and where they choose. E-learning can provide this education, but only if it is designed that way. For tens of thousands of years, people have come together to learn and share knowledge. Until now, people had to gather in the same place at the same time. Today, however, the technology of the internet has eliminated this requirement. Thanks to a new development called e-learning (Horton, 2006, p. 1), anyone can learn anything, anytime, anywhere, quickly.
In this regard, three leading theories about learning are used in this study to describes how people learn. Understanding educational theory will help to design and implement an effective online learning environment.

First, is the Theory of Behaviorism. Behavior theorist focus on observable behaviors, thus discounting independent activities of the mind. Behaviorism defines learning as nothing more than the acquisition of new behavior based on environmental conditions. The psychological theory of behaviorism is used as an educational theory when the learning experience is based on a stimulus and a response and by rewarding behavior that will meet the educational goal and ignoring (or correcting) behavior that is not goal directed.

Large tasks are broken down into smaller tasks, and each task is learned in successive order. The process is called successive approximations. The traditional learning lab in which proper procedures are learned for a task is an example of behaviorist theory.

Secondly, the Social Cognitive Theory (SCT) is also included. In SCT, information is stored in schema. As new information is internalized, it is compared with existing information and knowledge. The schemas are then reorganized to accommodate the new information and thought patterns are altered. Sensory input is stored for several seconds, and the information disappears unless it is deemed important. If deemed important, the information will be stored in short-term memory. If the information continues to be important, it will be moved into long-term memory. Cognitive theory is used in the traditional classroom to impart information from the teacher to the student. The responsibility for learning lies with the student. A weakness of cognitive theory is its inability to explain human thought and learning.
Last is the Constructivism Theory that explains that learning focuses on interpreting the world and in constructing meaning. Learning is active and reflective which means there is doing, then reflecting about the doing and then rethinking about the doing. Action and reflection enable the student to integrate new knowledge with existing knowledge and experiences so that complex mental models can form. Learning is authentic, complex, and contextualized, resembling real-life experiences. Constructivist learning is process oriented and emphasizes collaboration and conversation among learners and teachers.
In the constructivist approach, instruction is inductive and from the bottom, up. The instructor is a model and a coach who encourages exploration of ideas in learner-centered and learner-generated environment. Constructivism engages learners in an active learning process.

Although lectures may be well-written and well-delivered, they often pass from the ear to the hand leaving the mind untouched. The active learning process places responsibility on the learner and lends itself to a wider range of learning styles. If the student is to construct meaning from content, faculty, activities, and peers, then learning environments must be rich with strategies and resources.

The way an online learning environment is designed is largely affected by the teacher's philosophy of learning and understanding of educational learning theories. As educators, it is important we reflect upon the nature of how people learn and consciously utilize educational theory as the foundation to construct meaningful learning experiences in our online classrooms.

In order for meaningful learning to occur according to Jonassen, Howland, Marra and Crismond (2008), the task that students pursue should engage active, constructive, intentional, authentic, and cooperative activities. Rather than testing inert knowledge, educators should help students to learn to recognize and solve problems, comprehend new phenomena, construct mental models of those phenomena, and given a new situation, set goals and regulate their own learning (learn how to learn).
Incorporating a constructivist approach to designing and implementing online learning can provide the instructor and student with a variety of learning opportunities achieving the objective of meaningful learning. (Jonassen et al., p. 3).

Figure 1. Paradigm of the Study
A representation of Jonassen's characteristics of meaningful learning

On the other hand, this study is based on the concept and principle of forensic ballistics examination which states that bullets fired from a rifle will have more energy than similar bullets fired from a handgun. More powder can also be used in rifle cartridges because the bullet chambers can be designed to withstand greater pressures (50,000 to 70,000 for rifles psi vs. 30,000 to 40,000 psi for handgun chamber). Higher pressures require a bigger firearm with more recoil that is slower to load and generates more heat that produces more wear on the metal. It is difficult in practice to measure the forces within a gun barrel, but the one easily measured parameter is the velocity with which the bullet exits the barrel (muzzle velocity). The controlled expansion of gases from burning gunpowder generates pressure (force/area). The area here is the base of the bullet (equivalent to diameter of barrel) and is a constant. Therefore, the energy transmitted to the bullet (with a given mass) will depend upon mass times force times the time interval over which the force is applied. The last of these factors is a function of barrel length. Bullet travel through a gun barrel is characterized by increasing acceleration as the expanding gases push on it, but decreasing pressure in the barrel as the gas expands. Up to a point of diminishing pressure, the longer the barrel, the greater the acceleration of the bullet. (Volgas, Stannard and Alonso, 2005)

As the bullet traverses the barrel of the firearm, some minor deformation occurs, called setback deformation. This results from minor (rarely major) imperfections or variations in rifling or tool marks within the barrel. The effect upon the subsequent flight path of the bullet is usually insignificant. (Jandial et al, 2008)

Therefore, to determine the characteristics of the bullet in the Bullet ID, the students should bear in mind that bullets fired through rifled firearms receive both the class and individual characteristics of the barrel from which they are fired. These random and class characters define the characteristics of bullet.
The bullet shows the primary markings left behind by the gun barrel's lands and grooves and reveals the fine striations on all marks. The various class characteristics of bullet include caliber, number of lands and grooves, twist direction, and width of the lands and grooves. Individual characteristics of the fired bullet(s) and fired cartridge case(s) includes the striation marks present on the fired bullet(S) and impression marks on fired cartridge case(s) respectively.

Therefore, the students should identify the number of lands and grooves in the fired bullet. On discharging a firearm, the lands and grooves present in the bore of the firearm caused the bullet to spin as it travels through the length of the barrel. The high pressure created while propelling out the bullet causes the bullet to be pressed and scraped against the rifling. As a result, the fired bullet comprises the characters of the lands and grooves.

In addition, the student will also identify the direction of twist. The rifling present in the barrel is either twisted to left or right, which in turn causes the bullet to rotate as it passes through the bore, which ensures gyroscopic stability in its flight.

Moreover, they are also required to measure the width of lands and grooves. It is a characteristic of a bullet that is defined as the distance between the two lands present on the fired bullet.
Furthermore, the students are also required to identify the pitch and depth of lands and grooves. Depth of the lands and grooves describes how deep the raised portion of the barrel is to the actual caliber of the firearm. On the other hand, the pitch is the angle of the groove edge concerning the width and steepness of the groove. All these characteristics of a bullet are the ones that are imparted from a firearm onto the bullet.

Most importantly, the students should identify the caliber of the firearm used. The caliber of the weapon is the diameter of the bore of the weapon that is measured from land to land. This class character is also imparted during the making of the fired bullet.

On the other hand, students should also be able to identify the individual characteristics of bullets. These are the properties of physical evidence that are unique to particular evidence. Striations produced on the fired bullets due to the rifling are the unique characteristic of a fired bullet.

The striations are imparted as lands and grooves inside the barrel are imparted along with the striation on the bullets when fired. The various striation marks found are landmarks, these are defined as the marks found on a fired bullet caused by its contact with the elevated portion of the firearm's bore. It appears as slight scratches on the body of the fired bullet. Another is skid marks. These are the unique characteristics of bullets found as marks caused when a bullet is fired from a revolver. Lastly, stripping marks. These marks are found on bullets fired from the loose fit barrel where the rifling is badly worn out. The striations in the lands and grooves from a fired bullet provide a direct link to the bore of a particular weapon.

Hence, Class characteristics are usually measurable features of a specimen which is restricted to the group of the specimen. On the other hand, individual characteristics are patterns produced by the random irregularities of a tool surface and are unique to a particular specimen.
All these various characteristics of the bullets, including the class and the individual characteristic, helps in determining the firearm from which a particular can be fired, which in turn helps narrow down the perpetrator.

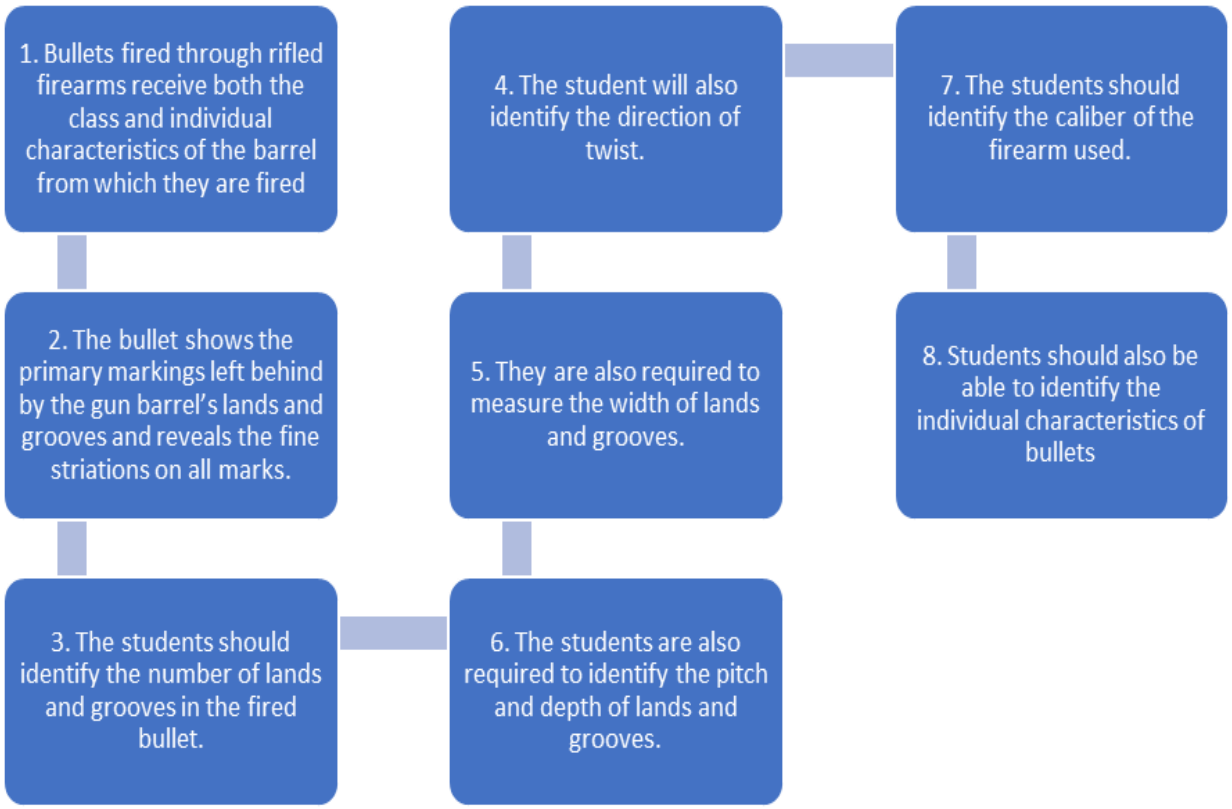


Figure 2. Conceptual Framework of Bullet Identification

Statement of the Problem

This study will be conducted to develop a mobile application which will be named as the Bullet Identification (Bullet ID).

Specifically, it will seek answers to the following problems.
1. What framework can be designed in the Bullet Identification?
2. What features can be integrated in the proposed system?
3. What is the extent of usability of the proposed system?
4. What is the level of knowledge and skills of students before and after the use of Bullet ID?
5. Is there a significant difference between the level of knowledge and skills of criminology students before and after the use of the Bullet ID?

DESIGN AND METHODOLOGY

This chapter presents the research design and methodology, population of the study, data gathering tool, data gathering procedure, and treatment of data.

Research Design and Methodology

This study will be conducted using Developmental Research design. This research design is defined as an interactive, cyclic process of development and research in which theoretical ideas of the designer feed the development of products that are tested in classroom testing, eventually leading to theoretically and empirically founded products, learning process of the developer and (local) instruction theory (Ibrahim, 2016).

In 2007 Rita et al. introduced a revised definition of developmental research. It is defined as a systematic study of design development and evaluation process with the aim of establishing an empirical basis for the creation of instructional and non-instructional products and tools and new or enhanced models that govern development. The revised definition clearly identifies the purpose of developmental research such as initiating both instruction and non-instructional gadgets that run improvement of instruction.

Similarly, from the area of curriculum design, Akker(1993) defined developmental research based on its purposes which are: (1) Supporting the development of prototypical products which include providing empirical evidence for their effectiveness, and (2) Generating methodological decision for the design and evaluation of the production. In this approach, the major aim of developmental research is to inform the decision-making process during the development of a product or a program in order to improve the product or the program being developed.

In this regard, the researcher will use the Agile Software Development Methodology. According to Stackify (2017), Agile Methodology is an approach that is people-focused, results-focused to software. It involves planning, self-organization, and short delivery times. It's flexible, fast, and aims for continuous improvements in quality. It abandons the risk of spending months or years on a process that ultimately fails because of some small mistake in an early phase. It relies instead on trusting employees and teams to work directly with customers to understand the goals and provide solutions in a fast and incremental way. In connection, the researcher will follow the seven phases of software development.

1. Planning

In the planning phase, the researcher and his collaborator will estimate the project cost, and created timetable with target goal. The researcher planned the project based on the user stories.

Planning clearly defined the scope and purpose of the application. It also sets boundaries to help keep the project from expanding or shifting from its original purpose.

2. Define Requirements

Defining requirements is considered part of planning to determine what the application is supposed to do, and the requirements to do it. Requirements also include defining the resources needed to build the project.

The researcher will start defining requirements by gathering user story and brains storming with his collaborator as to what features are needed in the system.
The major functional requirements for the Bullet ID app are –

i. The user shall be able to capture images of the bullet to be able to identify the twist of rifling and compare its individual characteristics.
ii. The user shall input to the interface the required data such as caliber or bore diameter, numbers of lands and grooves, twist of rifling, and the width of lands and grooves.
iii. The user, after inputting all the needed data will be able to click the search button for the system to automatically search the match class characteristics in the app.
iv. The user shall be able to view the result and will be able to identify what type of firearm was used to discharge the sample fired bullet.
v. The user will be able to input his/her observation/conclusion in the textbox.

3. Design and Prototyping

The Design phase models the way a software application will work. Some aspects of the design include:
Architecture – Specifies programming language, industry practices, overall design, and use of any templates or boilerplate.
User Interface – Defines the ways customers interact with the software, and how the software responds to input.
Platforms – Defines the platforms on which the software will run, such as Apple, Android, Windows version, Linux, or even gaming consoles
Programming – Not just the programming language, but including methods of solving problems and performing tasks in the application
Communications – Defines the methods that the application can communicate with other assets, such as a central server or other instances of the application
Security – Defines the measures taken to secure the application, and may include SSL traffic encryption, password protection, and secure storage of user credentials.

Prototyping can be a part of the Design phase. A prototype is like one of the early versions of the software. It demonstrates a basic idea of how the application looks and works.

4. Software development

This is the actual writing of the program. The coding process includes many tasks. Finding and fixing errors and glitches is also conducted in this phase. Tasks often hold up the development process, such as waiting for test results or compiling code so an application can run.

5. Testing

Testing will be done in a specific environment. Testing should ensure that each function works correctly. Different parts of the application were also tested to work seamlessly together. Test for performance was also conducted to reduce any hangs or lags in processing.

The testing phase helps reduce the number of bugs and glitches that users encounter. User's feedbacks were considered to improve the application. This leads to a higher user satisfaction, and a better usage rate.

6. Deployment

In the deployment phase, the application will be made available to users. It is done by downloading the application on a smartphone.

7. Operations and Maintenance

In this phase, users discover bugs that weren't found during testing. These errors need to be resolved, which can spawn new development cycles.

Population and Locale of the Study

The population of the study will be the developer of the bullet id system. He is a registered electronics and communication engineer, a software developer, a faculty member and research adviser at Philippine College of Science and Technology. The researcher will also include the end-users of this system, the criminology students and instructors of the same institution.

Data Gathering Instrument

A survey questionnaire based on ISO 9241-11 will be used to gain information that help in the formulation of answers posed in this study. The first part will be the Usability Test for Effectiveness and Efficiency of the System and the second part is the System Usability Scale for Satisfaction that includes 10 questions which the respondents will answer.

Participants will rank each question from 1 to 5 based on how much they agree with the statement they are reading. 5 means they agree completely, 1 means they disagree vehemently. This will be done immediately after they personally tested the usability of the Bullet ID.

The answers stipulated in the questionnaires will be supplemented by the results of interview and observation to acquire more accurate and sufficient data for analysis.

The data in problems number 1 and 2 will be gathered by means of interview, note taking and observation from the researcher's collaborator. The data in problem number 3 will be from the answers of the criminology students and instructors.

Data Gathering Procedure

The first step to be followed by the researcher in data gathering will be the development of the bullet identification system. This will start when the study gained approval from the defense panel. Thereafter, the researcher will immediately ask his collaborator to develop the system based on the framework and features stipulated by the researcher. After the system will be developed, the researcher will conduct a test of the system to identify its functionality, bugs or glitches. Lastly, after the test, all glitches and bugs were fixed the researcher will conduct pilot testing to measure the usability of the system.

Ethical Consideration

This study will be guided by the ethical principles on research with human participation by the Leeds Metropolitan University (Leeds Metropolitan University, 2006). In this regard, the research ethics was focused on requirements of voluntary participation, informed consent, confidentiality and the personal safety of the participants and the researcher.

The participant will not be forced nor coerced to participate in this study. He can decline to answer the question for any reason. He can also withdraw his participation in this research verbally. Debriefing was also conducted to stabilize the psychological condition of the participant. Moreover, strict confidentiality and anonymity of the participant will be observed and maintained.

Treatment of Data

To answer problem number 1 and 2, the data gathered will be analyzed narratively. On the other hand, problem number 3 will be analyzed statistically using the Usability Metrics under ISO 9241-11. The usability metrics should include: (1) Effectiveness: The accuracy and completeness with which users achieve specified goals, (2) Efficiency: The resources expended in relation to the accuracy and completeness with which users achieve goals and, (3) Satisfaction: The comfort and acceptability of use.

1) Usability Metrics for Effectiveness

$$Effectiveness = \frac{\text{Number of tasks completed successfully}}{\text{Total number of tasks undertaken}} \times 100\%$$

Although one should always aim for a completion rate of 100%, according to a study carried out by Jeff Sauro (2015), the average **Task Completion Rate is 78%**.

2) Usability Metrics for Efficiency

Task Time = End Time – Start Time

Efficiency can then be calculated in Time-Based Efficiency

Where:

N = The total number of tasks (goals)

R = The number of users

n_{ij} = The result of task i by user j; if the user successfully completes the task, then N_{ij}=1, if not, then N_{ij}=0

t_{ij} = The time spent by user j to complete task i. If the task is not successfully completed, then time is measured till the moment the user quits the task

$$Overall\ Relative\ Efficiency = \frac{\sum_{j=1}^{R}\sum_{i=1}^{N} n_{ij}t_{ij}}{\sum_{j=1}^{R}\sum_{i=1}^{N} t_{ij}} \times 100\%$$

Taking the above equation:

N=The total number of tasks = 1
R=The number of users = 4
User 1: $N_{ij} = 1$ and $T_{ij} = 1$
User 2: $N_{ij} = 1$ and $T_{ij} = 2$
User 3: $N_{ij} = 1$ and $T_{ij} = 3$
User 4: $N_{ij} = 0$ and $T_{ij} = 6$
Placing the above values in the equation:

$$Overall\ Relative\ Efficiency = \left(\frac{((1 \times 1) + (1 \times 2) + (1 \times 3) + (0 \times 6))}{(1+2+3+6)}\right) \times 100 = 50\%$$

3) Usability Metrics for Satisfaction

User satisfaction is measured through standardized satisfaction questionnaires which can be administered after each task and/or after the usability test session.

The Test Level Satisfaction is measured by giving a formalized questionnaire to each test participant at the end of the test session. This serves to measure their impression of the overall ease of use of the system being tested. For this purpose, the SUS: System Usability Scale with 10 questions was utilized. Sauro recommends using SUS to measure the user satisfaction with software, hardware and mobile devices. Moreover, it consists of a very easy scale that is simple to administer to participants, thus making it ideal for usage with small sample sizes.

The respondents had ranked each of the questions in the questionnaire from 1 to 5, based on their level of agreement.

- For each of the odd numbered questions, subtract 1 from the score.
- For each of the even numbered questions, subtract their value from 5.
- Take these new values which you have found, and add up the total score. Then multiply this by 2.5.

The result of all these calculations is the score is out of 100. This is NOT a percentage, but it is a clear way of seeing your score. The average System Usability Scale score is 68. If the score is under 68, then there are probably serious problems with the system's usability which should be addressed. (J. Mifsud, 2015)

Here's an overview of how the scores were measured:

A. 80.3 or higher is an A. People love the site and will recommend it to their friends
B. 68 or thereabouts gets a C. Performance OK but could improve
C. 51 or under gets a big fat F. Make usability priority now and fix this fast.

Furthermore, to measure the level of knowledge and skills of the users, the researcher computed the mean value of all the scores of the users after the series of test were given.
Lastly, the compare if there is a significant difference in the level of knowledge and skills of the users who did not use the app and those who used the app, the T-test and ANOVA were used.

RESULTS AND DISCUSSION

This chapter presents, analyzes, and interprets the findings of the study based on the problems posited in the study.

Framework Used to Design the Bullet Identification System

This section explained the framework that was used to design the Bullet Identification System (Bullet ID) and the specified process of the system.

The Bullet ID is designed from a Front-End Javascript Framework. This is an open-source and free to use framework under the MIT License. It is one of the frameworks used in developing mobile applications that are compatible with Android ad IoS.

The Bullet ID designed is shown in Figure 1. The system was built using this lay-out. This framework used User Interface (UI) elements. The researcher decided to use a front-end framework because the Bullet ID do not need a server's database. The Bullet ID's main function is to identify what type of firearm was used to discharge the sample (fired bullet).

Software Requirements

These are the requirements for developing the app or running the app on a device are presented below.

For development:
Operating System: Windows 10
Platform: Front-End Javascript
Tools: Android SDK, React Native, ADT
Technologies used: Java
Debugger: Instabug
Emulator: Android API

For running on a device:
Operating System: Android 7.0/IOS 6.0 or higher Cellular capabilities

Hardware Requirements

For development:
Processor: i3 or higher
RAM: 4GB
SSD: 256GB

For running on a device:
Device: Phone or tablet running Android 7.0/IOS 6.0 or higher
Disk space: 17.30 MB (at the least)

System Architecture

The system provides a browser-based interface. The user inputs all the needed data and the result are also displayed in the browser. The main building blocks of the system is shown below

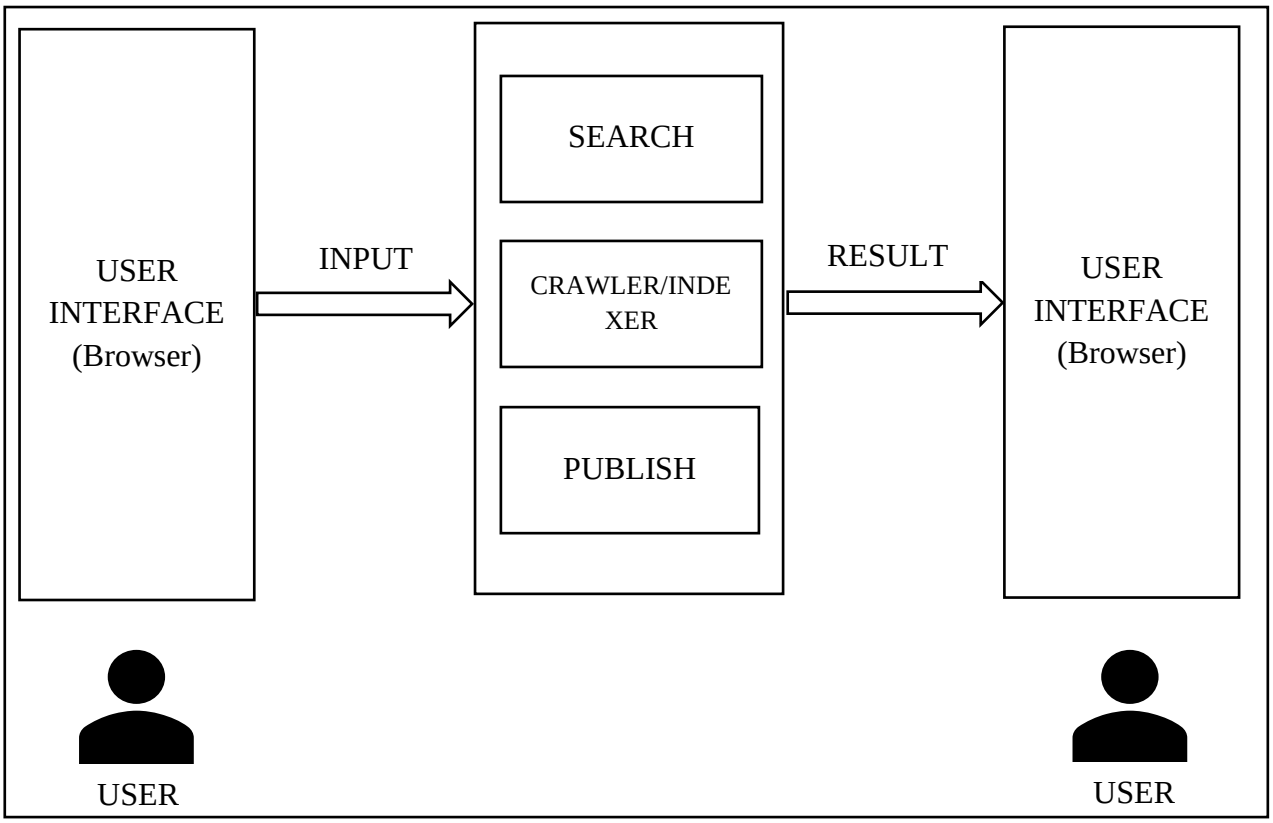


Figure 3. System Architecture

The different components in the architecture are:

User Interface (Browser)

The client component provides a simple administrative console and the search interface. The application administrative console provides for the publishing/registration of databases, making all the indexing configurations for a database and the scheduling of the indexing process. The search interface provides for user to enter the input data and a default view for showing the search results. The administrative console functions are hidden from the general end-users who only input data to the system and get the result of the search.

Publish Module

An existing data source is first registered with the system. The publish component or module builds the metadata by consulting the data source catalogue. The search system builds up its own information base when a data source is initially registered (published) with it.

Crawler/Indexer

The list of data source that needs to be search-enabled is given as input to the crawler with the configuration parameters specific to each of the data sources (through the publish module). The crawler

takes the input data source, scans through the tables and the data available in each of the given data source and builds up its own information base and creating certain index information about the data source and computing the data source statistics. The important index information stored about the data includes:

- The caliber/bore diameter of the bullet
- The direction of twist or twist of rifling
- The number of lands and grooves
- The width of lands and grooves.

Search/Query Processor

Search component takes care of fetching the right information from the participating data source(s), given the search words/numbers, based on the index information. For a given set of words/numbers, the search component provides interfaces to retrieve matching data from a set of published data source, and selectively identify the data that need to be searched within each data source identified based on the index information. The specific interfaces include for a given set of words/numbers:

- Find all the matching data
- Find all data in the data source that contain all or most of the words/numbers.

Use Case Diagram

A use case diagram is used to specify the functionality of the system from the point of view of a user. Each use case describes a logical task that may be performed by a user. It mainly shows the interaction between the system and the outside world.

The figure below shows that after the user input all the required data and click the search, the system will simultaneously fetch all the data from the data sources. After all these tasks were conducted, the system will now show the result of the query.

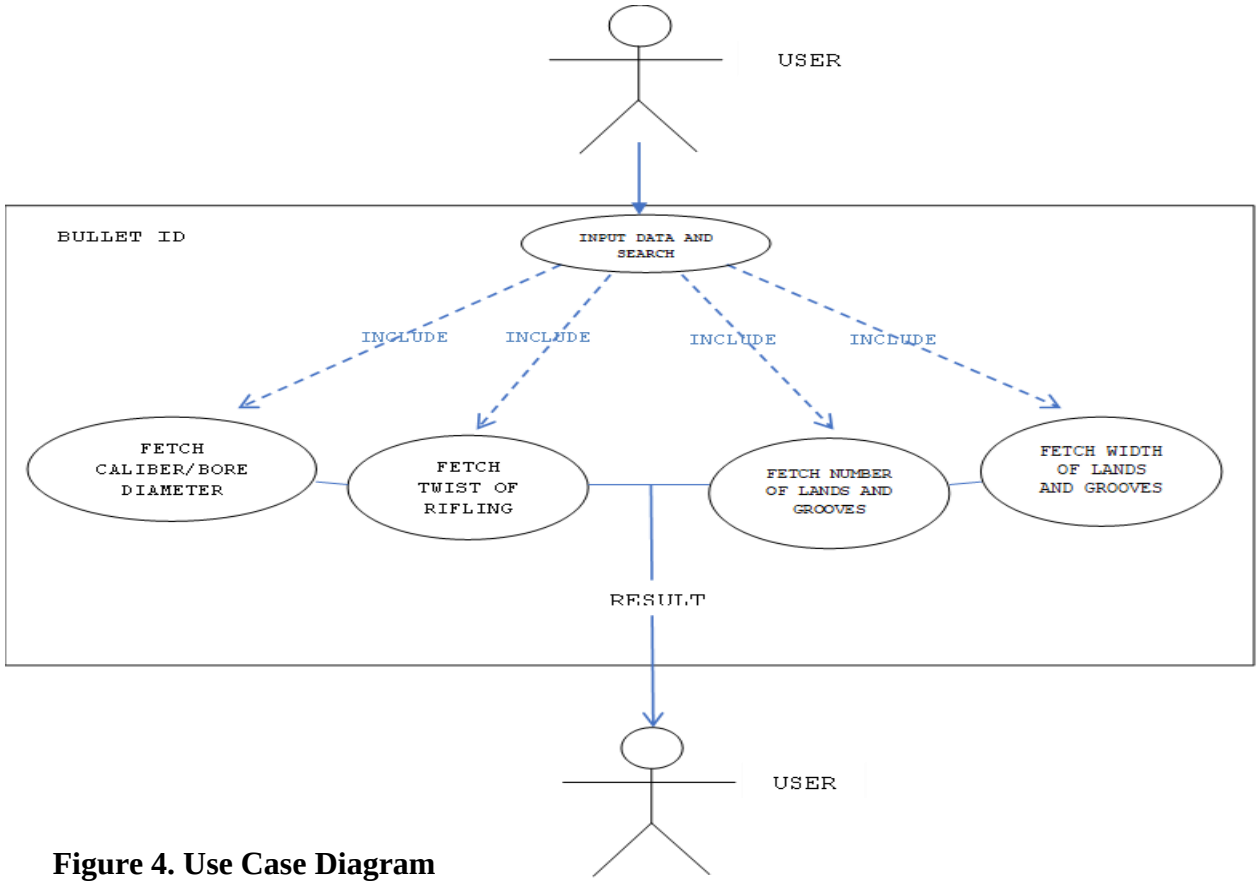


Figure 4. Use Case Diagram

Integrated Features in the Proposed System

Photo Capturing: This feature enables the user to capture images of the bullet by allowing the app to access the phone's camera. This feature is essential because the main objective of the app is to identify the firearm by examining the characteristics of the captured bullet.

Gallery View: This will enable the user to store the images in the phone's gallery taken from the camera. The user will access the gallery whenever he/she wants to conduct examination of the direction of twist or when comparing two fired bullets to identify Individual Characteristics.

Comparator View: This feature will enable the user to use app to simulate the feature of the Bullet Comparison Microscope. The user will open this interface whenever he/she wants to compare two fired bullets to examine or identify Individual Characteristics.

Class Characteristics Interface: This feature will enable the user to access an interface where he/she can input all the needed data such as the caliber/bore diameter of the fired bullet, the direction of twist or twist of rifling, the number of lands and grooves, the width of lands and grooves. After putting all the data, the user will be able to click the search button. Thereafter, the system will match the input data to the data source stored in the app to identify what make or type of firearm the bullet was fired.

Result Box: This feature will enable the user to view the result of the search. This is needed because the user will use the result in formulating his observation and conclusion.

Observation/Conclusion Textbox

This feature will enable the user to write his observation and conclusion on the examination he/she conducted.

Benefit of Using BIS

Learning and Innovation go hand in hand. In this Era of Innovation, a lot of things are getting evolved and so is education.

The use of BIS is a new technique to impart knowledge to criminology students. This includes exposing students to the kind of activities that engage them in learning through innovative ways. The introduction of BIS in the education sector will lead to the introduction of new learning methods. The activities or tasks available on the BIS will indulge the students into a healthy thought process and help them understand things from a different perspective.

As compared with other system related to firearms identification that mostly are web-based, the BIS is a mobile application that can be access even offline. In this regard, students with no laptops or computers can be able to use this innovation with the use of their mobile phones. A mobile phone can make a lot of tasks easy for the users and also saves a lot of time.

Similarly, the trend in education is changing there is a digitalization wave into education. E-Learning is the new need for the students. E-Learning mobile apps are getting popular day by day and that is due to its uniqueness of making learning fun for students.

Extent of Usability of the Proposed System Using the ISO 9241-11

Table 1

Usability based on Effectiveness of the Bullet Identification System

TASKS	FREQUENCY OF USERS WHO COMPLETED THE TASK	PERCENTAGE
TASK 1 – DOWNLOAD	40	100%
TASK 2 – INSTALLATION	40	100%
TASK 3 – CAPTURE IMAGE	40	100%
TASK 4 – SEARCH DATABASE	40	100%
TASK 5 - COMPARATOR	40	100%

Table 1 show the usability based on effectiveness of the Bullet Identification System. It shows from the table that all of the participants successfully completed the entire tasks that were performed during the pilot testing. This might be attributed to the fact that the system is user-friendly because of its simple design and features.

In his dissertation, Cazar (2020) cited an article entitled The Essence of Simplicity or Psychological and Social Foundation of the Mobile App Success, authored by Ossmium (2018). He quoted “simplicity becomes a key to app success in the Google Play and Apple App Store”. He clarified that one of the key elements in determining a mobile app's visual appeal is simplicity. But he went on to say that simplicity was applied to the information design, or the organization, structure, flow, and frame of interface components, in addition to the visual aspect of the mobile app. He also said that fewer steps in a particular

function of the mobile app would result in an acceptable evaluation and response from the users of the app.

Users will not sit through a lesson to use a mobile application (Crooks, 2017). The software should be simple to use and intuitive in this sense. There should not be any difficult features in the mobile app. The more functionality the software has, the more awkward it will be. Instead, concentrate on the few essential components. Keep things simple like this.

This means that the system's simplicity will lead to task completion because users will have to take fewer steps. In addition to the aforementioned point, 14% of smartphone owners reported deleting an app that was difficult to use (eMarketer). Intuitive navigation and overall usability are important features that users seek in mobile app experiences. Minimizing clicks and actions is a big win for mobile usability. It is far more difficult to select objects and input information on mobile than it is on desktop because there is no mouse or keyboard. Scrolling is preferred over clicking on mobile devices in particular. The optimized mobile app will keep clicks and field entries to a bare minimum.

In furtherance, Promethean (2018) stated that, for established institutions and educators, the idea of transforming education can be frightening. On top of teaching, time in the classroom and at home is already fully accounted for with planning, marking, and preparing for educational standards. If the school's goal is to incorporate technology into its tried-and-tested teaching methods, an uncomplicated approach to technology is an excellent first step.

Thus, simplicity allows students to concentrate on the desired outcome of a lesson, while technology encourages them to approach a subject from a variety of perspectives. Furthermore, attempting to do too much too soon can be counterproductive. As a result, technology may eventually impede student learning and create a stumbling block for experienced educators. The same way that new subject matter should be introduced gradually into lessons to avoid overloading students, the same approach should be taken when introducing technology. A gradual approach ensures effective uptake, avoids overwhelming classes, and allows both students and teachers to become acquainted with the technology.

Table 2
Usability based on Efficiency of the Bullet Identification System

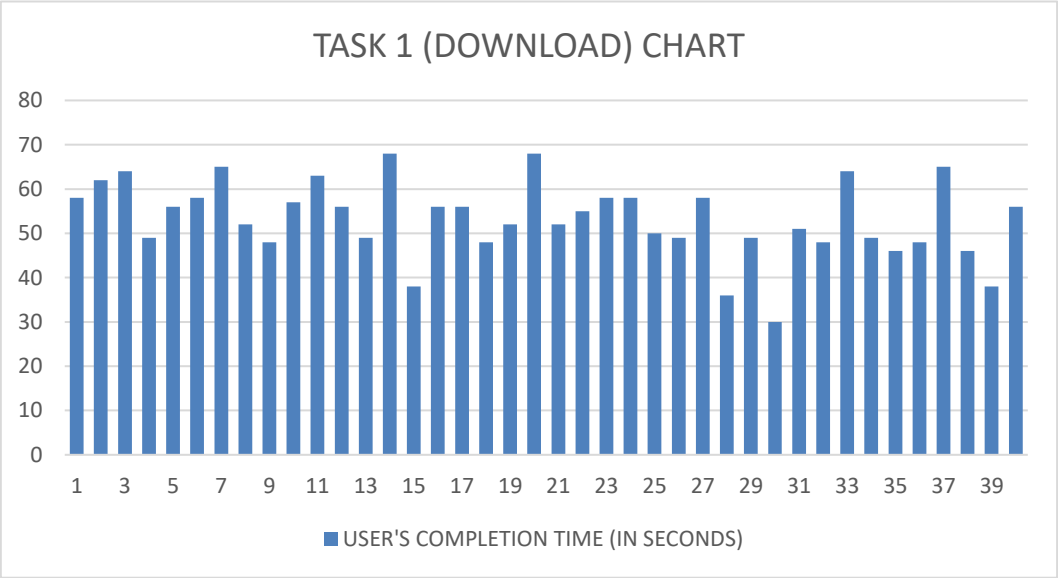
TASKS	∑ OF RATIO OF THE TIME TAKEN BY THE USERS WHO SUCCESSFULLY COMPLETED THE TASK	PERCENTAGE	AVERAGE TIME (SECONDS)
TASK 1–DOWNLOAD	5323	100%	53.23
TASK 2–INSTALLATION	2453	100%	24.53
TASK 3–CAPTURE IMAGE	1508	100%	15.08

TASK 4–SEARCH DATABASE	2256	100%	22.56
TASK 5-COMPARATOR	4415	100%	44.15
OVERALL RELATIVE EFFICIENCY		**100%**	

Table 2 shows the data of usability based on efficiency of the Bullet Identification System. It can be gleaned that all of the participants successfully completed the task in a certain period of time thus, having an overall relative efficiency of 100%. The specific data is shown in the succeeding chart to fully understand the result.

CHART 1

Usability based on Efficiency of the Bullet Identification System TASK 1

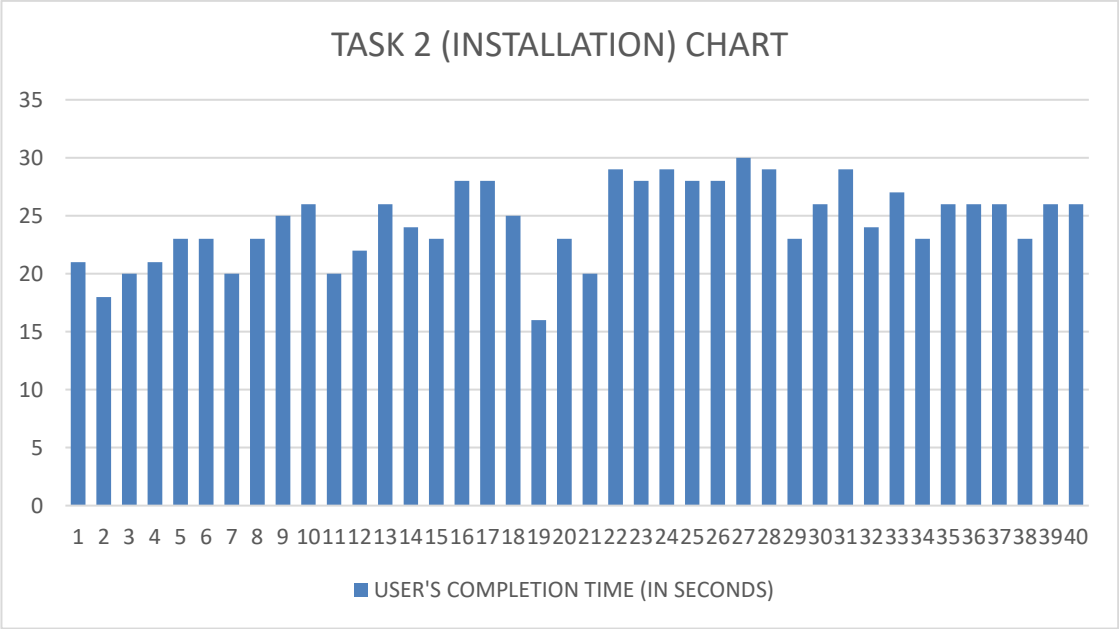


AVERAGE TIME: 53.23 seconds

The chart above shows the data of users who completed the task 1 which is the DOWNLOAD. All of the participants successfully downloaded the BIS in their respective mobile phone. It is shown in the chart that participant or user number 30 successfully downloaded the app in just thirty (30) seconds which is considered as the fastest among the forty (40) participants. On the other hand, participants or users number 14, and 20, downloaded the app in sixty-eight (68) seconds which is considered as the slowest among the participants. The average time for task 1 is 53.23 seconds.

CHART 2

Usability based on Efficiency of the Bullet Identification System TASK 2

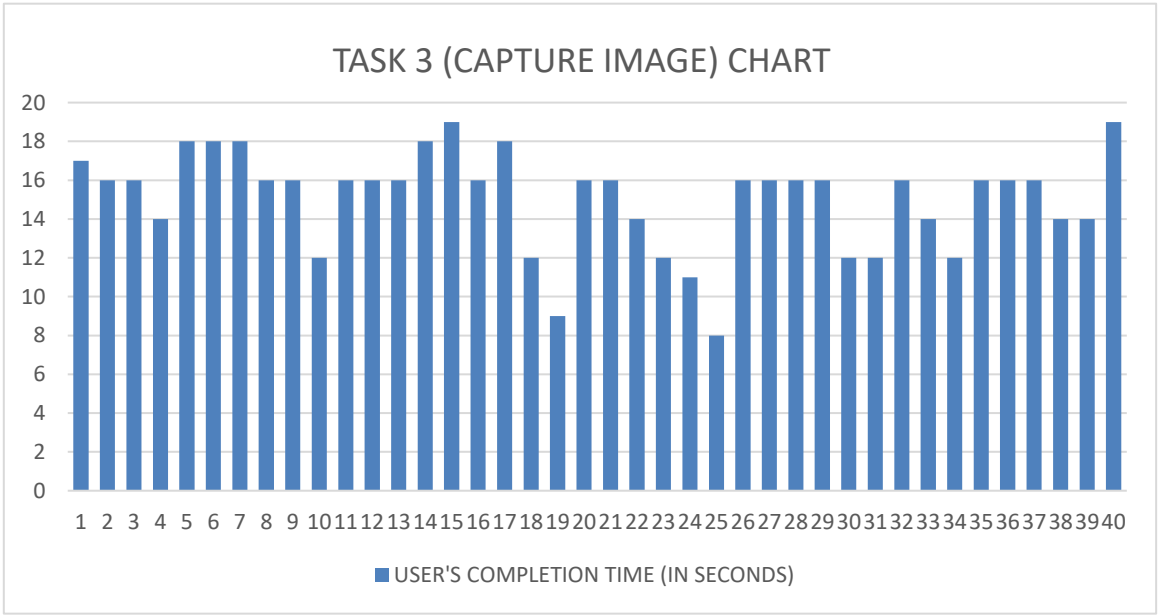


AVERAGE TIME: 24.53 seconds

Moreover, the chart presented above is the data of the users who successfully completed the task 2 (INSTALLATION). It is shown in the chart that all of the participants successfully installed the Bullet ID in their mobile phones. Specifically, participant number 27 took 30 seconds to install the Bullet ID and participant number 6 took only 6 seconds to install the app to his mobile phone. The average time to install the app is 24.53 seconds.

CHART 3

Usability based on Efficiency of the Bullet Identification TASK 3

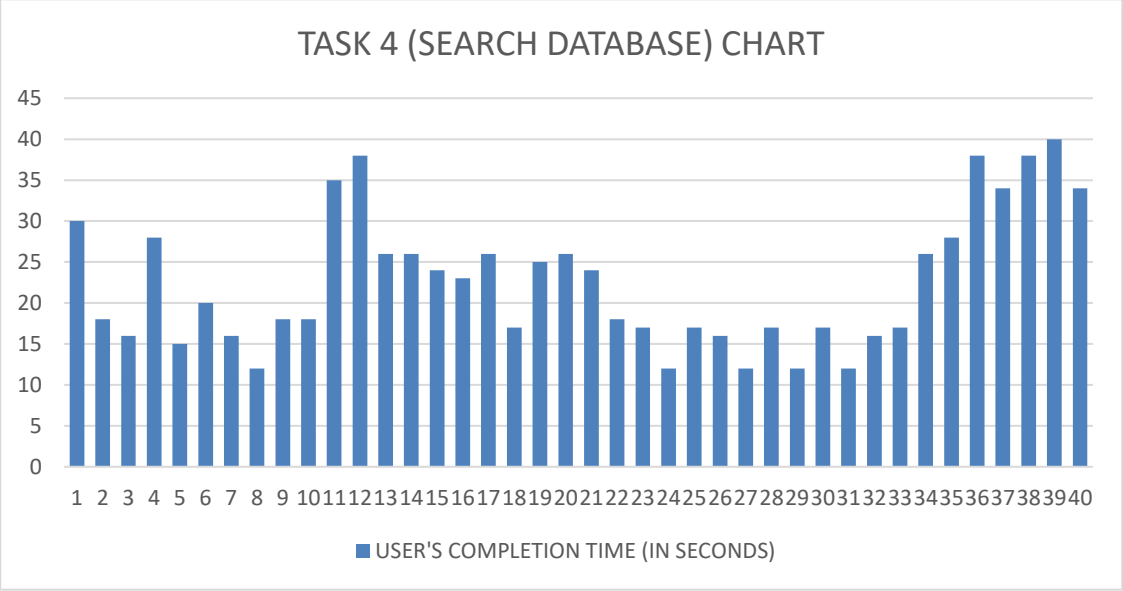


AVERAGE TIME: 15.08 seconds

Furthermore, the chart above is the data of the users who successfully completed the task 3 (CAPTURE IMAGE). The average time to add contacts in the Bullet Id is 15.08 seconds with 19 seconds as the slowest time recorded and the fastest time is 8 seconds.

CHART 4

Usability based on Efficiency of the Bullet Identification TASK 4

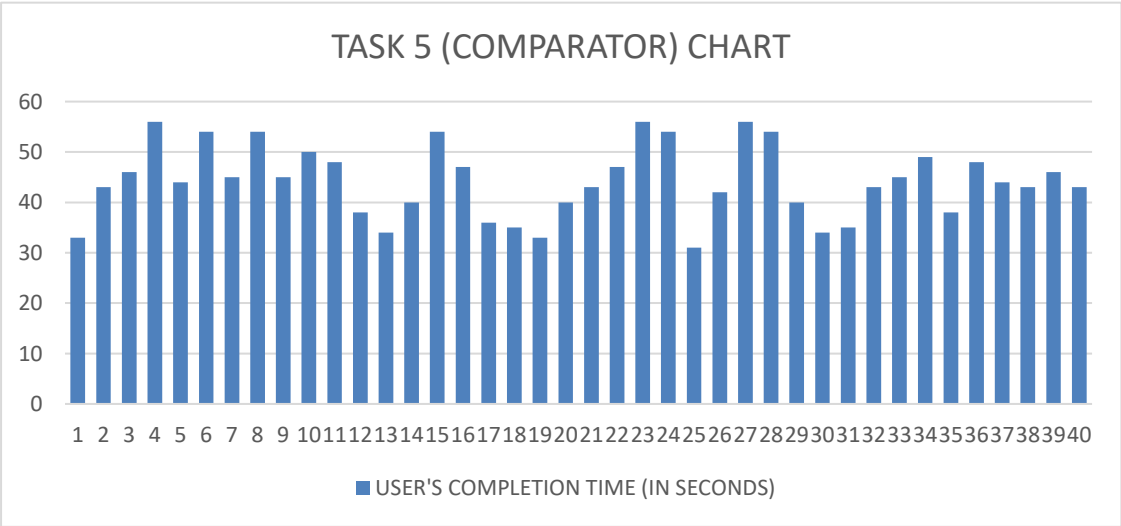


AVERAGE TIME: 22.55 seconds

The chart shown above is the data of the users who successfully completed the task 4 which is to search database to the contacts added by the users. The average time of the Bullet ID to search database is 22.55 seconds. The slowest time recorded in the pilot testing is 40 seconds. The fastest time recorded to complete the task is 12 seconds.

CHART 5

Usability based on Efficiency of the Bullet Identification TASK 5



AVERAGE TIME: 44.15 seconds

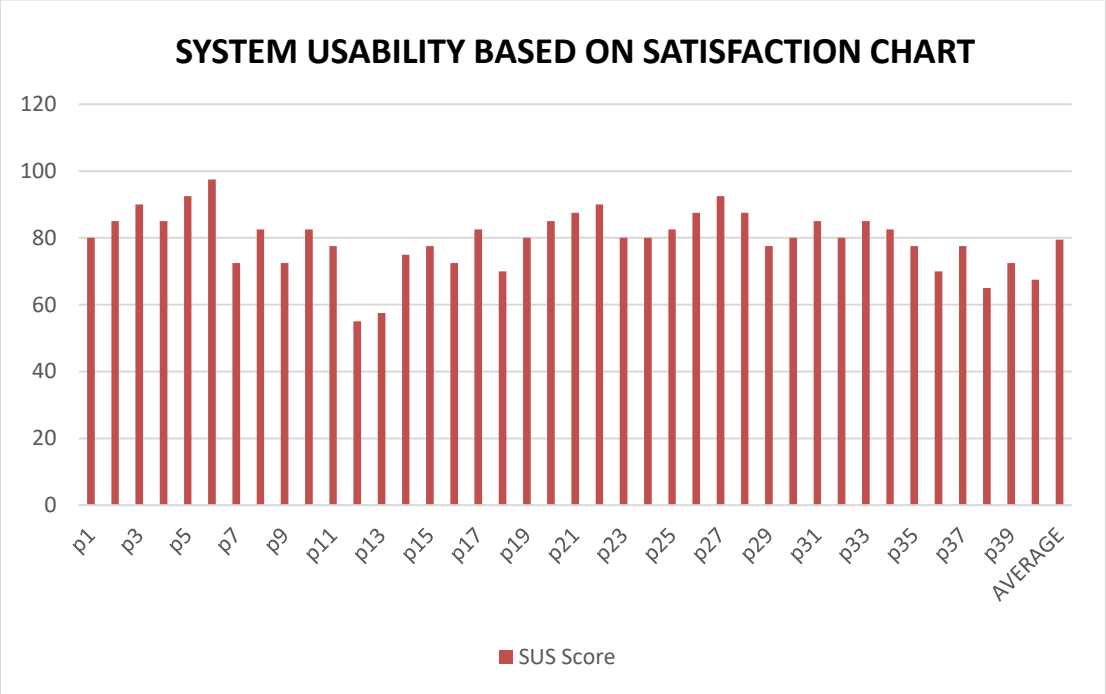
Lastly, the chart above shows the data f the users who successfully completed the task 5 which is the comparator. It shows that slowest time to complete the task is 56 seconds and the fastest time recorded is 31 seconds.

Overall, many factors influence the Bullet ID's usability in terms of efficiency. For example, the network connection in the user's location, the Read-Only Memory (ROM), the Random Access Memory (RAM), and the device's Operating System (OS) all have an impact on downloading and installing the app. This means that the issue with the delay or the benefit of quick downloading is not due to the app itself, given its small size of 17.30 megabytes, but rather to the device and network connection.

Because it is dependent on the users' ability, the efficiency of capturing image has little impact on the overall system. The steps are the same for all users in the principle of capturing image to a mobile phone. Furthermore, the efficiency of comparator is dependent on the resolution of the phone's camera of the users. Because of that common issue, some users took some time to compare the image captured in the comparator.

Thus, the Overall Relative Efficiency of the five tasks is 100% respectively. This indicates that despite minor issues such as device specifications, the tasks were successfully completed by the users. This means that the usability of the device is efficient.

CHART 6
Usability based on Satisfaction of the Bullet Identification System



AVERAGE SUS OF BIS: 79.50

The chart above shows the data of usability based on satisfaction. According to ISO 9241-11, score with 80.3 and above indicates high usability of the mobile application. Scores within the range of 68 or

thereabouts meaning the app is doing OK but could improve and those scores below 68 indicate low usability.

Based from the data shown above, the highest SUS score is 97.50 and the lowest SUS score is 55. Having an average SUS of 79.50, the Bullet ID had surpassed the average level of usability based on satisfaction and could be improved to meet the high usability level.

The results show that users are satisfied with the usability of the Bullet ID, which could be attributed to the fact that the app met the users' expectations after demonstrating its usage and features. According to a study conducted by Liu et al. (2018), responsiveness and content of a mobile app that meets users' expectations can increase satisfaction. In this case, the Bullet ID satisfied the users by meeting these criteria. The Bullet ID's features, which can be considered the content of the mobile app, and the 100% success rate, which can be considered the responsiveness of the mobile app, lead to users' satisfaction. Users were pleased with the Bullet ID's usability because it is designed to be compatible with Android and IOS operating systems and can compare to images of the bullet that simulates the functions of a real bullet comparison microscope. Moreover, the simplicity of navigating the app can also be a factor that made the users satisfied.

However, the descriptive equivalent of Bullet ID's SUS average which is 79.50 is "okay but could improve". This means that there are still features that could be improved prior to its full usage. For example, the dimension of the captured image can affect its usability. This might cause weak conclusion or findings because the users will just compare the captured image in its 1-dimension shot. The database could also improve by adding more data that can be used to facilitate searching class characteristics. The aesthetic or the visual designs could also be improved to attract the users. According to Wangenheim et al., (n.d.) visual aesthetics is increasingly being recognized as an important factor in perceived usability, interaction, and overall evaluation of user interfaces, particularly in mobile applications. The aesthetics of user interfaces are an important component of usability as a software product quality. The beauty or pleasing appearance of an interactive software system's user interfaces is referred to as visual aesthetics. It is regarded as a critical factor in the user interface's perceived and effective usability, subjective user satisfaction, trust & credibility, and preference.

Therefore, the ease of use, perception of value, utility, and efficiency of the overall experience all contribute directly to how a user feels about the app. For the students, mobile app usability promotes learnability. A successful app needs to be intuitive, and it should take very little time for a user to achieve a certain degree of familiarity with the interface. If a user encounters an issue, a solution should be easily discoverable.

Knowledge and Skills of Students Before and After the Use of Bullet ID.

Table 3

Mean and T-Value Scores of the Knowledge and Skills of Students belongs to Group 1 (Non-user of Bullet ID)

	Pre-test	Post-Test
Mean	15.1	19.75
T-Value	**-4.01**	

(The t-value is -4.0144. The p-value is .000068. The result is significant at p < .05.)

Table 3 shows the mean and t-value scores of the knowledge and skills of students belongs to Group 1. These students are the one who underwent Pre-Test and Post-Test regarding Forensic Ballistics without the use of Bullet ID. It shows that, in the Pre-test, the students scored 15.1 (Mean Value) and in the Post-test, students scored 19.75 (Mean Value). This indicates that the result is significant with .05 margin of error.

Therefore, there is a significant difference in the acquired knowledge of the students even they did not use the Bullet Id. This means that plain lecture and discussion of the topic will still help the students gained knowledge and skills. This might be attributed to the fact that the class was conducted in face-to-face mode. This means that face-to-face classes is still effective to the students even if they did not use the Bullet ID.

Furthermore, the lecturer is an expert in the field of forensic ballistics that is why he can easily deliver the knowledge and skills to the students in an effective manner. In addition, this only shows that traditional teaching is still effective amidst technological advancement is already introduced to the schools and to the students.

In an article published by Balliu and Belshi (2017), they stated that, many experienced teachers are still effective even if they still do direct lecturing and teacher-provided guidelines to convey scientific information. This method emphasized teaching processes are led by teachers where in students anticipate to listen to lectures and learn by them. Tests and exams are the most effective tools for assessing student performance and the primary indicator of knowledge acquisition. Students learn what they need to be successful in life by using traditional methods of teaching in formal education. Traditional teaching methods have long been regarded as positive and successful; however, they have some drawbacks, particularly in the current scale of development, when technology has greatly improved teaching effectiveness, making teaching-learning processes more appealing and enjoyable by enhancing interactive relations among students as well as through the scientific and educational information schools provide.

Table 4
Mean and T-Value Scores of the Knowledge and Skills of Students belongs to Group 2 (User of Bullet ID)

	Pre-test	Post-Test
Mean	15.05	25.88
T-Value	**-12.87**	

The t-value is -12.86624. The p-value is < .00001. The result is significant at p < .05.

Table 4 shows the mean and t-value scores of the knowledge and skills of students belongs to Group 2. These students are the one who underwent Pre-Test and Post-Test regarding Forensic Ballistics with the use of Bullet ID. It shows that, in the Pre-test, the students scored 15.05 (Mean Value) and in the Post-test, students scored 25.88 (Mean Value). This indicates that the result is significant with .05 margin of error.

Therefore, there is a significant difference in the acquired knowledge of the students after they had used the Bullet Id. This means that the mobile app also helped the students understand the topic and able to gained knowledge and skills. This might be attributed to the fact that technological advancement in learning is a great factor to engage the learners in the topic. This also means that the mobile app is a supplemental means to increase the knowledge of the students in a certain field like forensic ballistics.

Furthermore, students nowadays are fond of technology and mobile app that is why, adding up a technology like Bullet ID in their learning activities will increase their knowledge and skills. In fact, educational learning apps are intended to engage and entertain students. A learning app provides knowledge enhancement, tailored learning experiences, improved engagement, access to online study material, ease of communication, and, most importantly, remote access.

According to Ahmed (2022), following the global pandemic, there has been a massive expansion of technology in the education sector. The entire industry is discovering new ways to do things with technology on its side. Technology has not always been used in education, but the use of educational applications has been limited. Using technology was once optional, but it is now required. This has resulted in the adoption of educational software development through mobile applications, allowing businesses, particularly those in the education sector, to reach new heights. There was a clear demand for technical tools and systems that allowed professors to communicate with their students, track their learning progress, and distribute their courses during compulsory distance learning.

Moreover, Mansoor (2022) also noted that, with the advancement of technology in all fields, there has been tremendous progress in the field of education through the integration of innovative technology and education.

Lastly, mobile technology is incredible. It is one of the most revolutionary productivity tools ever created, but it does not stop there. Smartphones and tablets can be used to teach someone new skills and learn new

things. The quality of an educational app is an important factor in the ever-changing world of teaching and education, and it can significantly enhance the learner's educational experience.
Thus, digitizing education to supplement traditional education systems is the ideal solution for improving literacy and education around the world.

Table 5
Analysis of Variance (ANOVA) Result of the Scores of Group 1 (Non-User of Bullet ID) and Group 2 (User of Buller ID)

Result Details				
Source	***SS***	***df***	***MS***	
Between-treatments	3145.1188	3	1048.3729	***F* = 51.15014**
Within-treatments	3197.375	156	20.496	
Total	6342.4938	159		

The f-ratio value is 51.15014. The p-value is < .00001. The result is significant at p < .05.

Table 5 shows the ANOVA result of the scores of Group 1 (Non-User of Bullet ID) and Group 2 (User of Buller ID). It is noted that the f-ration value is 51.15014 with a .05 margin of error. This means that there is a significant difference between the scores of Group 1 (Non-User of Bullet ID) and Group 2 (User of Buller ID).

Although, both groups increased their knowledge and skills after their respective Post-tests, it is noted that in the ANOVA result, there is still significant difference. This might be because of the fact that Bullet ID indeed supplemented the knowledge and skills of the students. This means that, the Bullet ID is a great tool to compliment traditional learning experience of the students. With the use of the Bullet ID, the students are able to appreciate more of the topic specially if the class is conducted online where laboratory equipment like comparison microscope is not available in their homes. With the help of Bullet ID, student will be able to simulate the laboratory procedures in comparing test fired bullets in the comfort of their homes.

Furthermore, Ahmed (2022) noted that, educational apps can facilitate the learning style according to curriculum requirements and it will accelerate the learning process and as a result prove to be beneficial to the user. According to research, in this tech-savvy era, students can have more access with mobile phones and they are interested to learn move away from classroom. Using mobile phone for education purpose helps students to progress faster, but also improve their ability to use technology. These apps can be used anywhere and anytime. Learning is a constant process and the focus has now completely shifted to eLearning. Due to the mobile phones and the various feature-oriented applications, students can learn at their place and take their time at understanding things, as everything is just a click away.

CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the conclusions and recommendations of this research.

Conclusion

Based on the findings of the study, the researcher concludes that:

1. The Bullet Identification System (Bullet ID) is a mobile application designed from a Front-end Javascript Framework that will simulate the functions of a comparison microscope using smartphone.
2. The features of Bullet ID is designed to facilitate the learning experience of the students specially those undergoing online studies and those schools with lack of laboratory equipment like comparison microscope.
3. The Bullet ID is accepted by the users as a usable tool in the in their learning experience. It is suited for students and instructors because it is user-friendly.
4. Both groups of students increased their knowledge and skills in forensic ballistics by using traditional method of learning and with aid of Bullet ID.
5. There is a significant difference on the knowledge and skills of the students thus, making the Bullet ID as an essential tool to supplement the traditional method of teaching forensic ballistics.

Recommendations

The researcher hereby recommends the following:

1. Develop a stable database to increase the class characteristics information and to be able to save more photos of bullets that will serve as standards for comparison purposes of individual characteristics.
2. Developed a 3-dimensional perspective of the photos or images to have a better conclusion in the examination and comparison of individual characteristics.
3. System updates for fixing bugs and glitches, addressing lags and delays in the capturing, storing and searching images.
4. The Bullet ID should be re-evaluated to identify its usability for other possible users such as students and instructors from other schools nationwide.

2. Authors' Biography

Geraldo P. Roxas received the B.S. degree in Criminology from University of Luzon (formerly Luzon Colleges) in 1986. During 1988-1990, he finished his degree in B.S, Marine Transportation in Pangasinan Merchant Marine Academy (PMMA). In January 15, 1996 he entered the Philippine National Police via lateral entry with an initial rank of Police Inspector (Police Lieutenant) and optionally retired in February 1, 2016 with a rank of Police Colonel. While in the service as a police officer, he continuously served as a Criminology professor from 1994 up to this time in Philippine College of Science and Technology. He also received his M.S. degrees in Development Management and Criminology from Pangasinan State University in 2000 and University of La Sallete in 2012 respectively. At present he is taking up Doctor of Philosophy in Criminal Justice with specialization in Criminology at the University of the Cordilleras.

Robino D. Cawi is the current Dean of the College of Criminal Justice Education at the University of the Cordilleras in Baguio City. He is also the former Dean of CICOSAT Colleges in San Fernando City, La Union and Easter College Inc. in Baguio City. In march 2003, he was awarded by the Professional Regulation Commission as the Top 5 in the Criminologists Licensure Examination. He also received Presidential Citation Award, Outstanding Criminologist Award, Distinguished Criminologist Award,

Outstanding Educator, and Excellent Service Award, all were given by the Professional Criminologists Association of the Philippines.

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