Using Game-based eLearning to Build Resilience to Natural Hazards in the Caribbean

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Abstract

The Caribbean and Latin America is the second most disaster-prone region globally. Between 2000 and 2019, the Caribbean region faced over 170 hurricanes, 148 tropical storms, eight earthquakes, and several floods. Generally, disasters have an adverse economic, social and psychological impact; however, it should be possible to reduce the severity through planning, preparation, and appropriate, timely action. Some natural hazards, such as hurricanes, are cyclical and should only become disasters when there is damage or loss of resources, lives and livelihood. Gamebased blended learning focused on prevention and preparation can build knowledge and awareness, contributing to building resilience, specifically, the ability to withstand and recover from natural hazards. This article postulates that resilience should be encouraged from a young age because resilient children can become resilient adults and contributors to a society capable of functioning during crises or difficult situations, including natural hazards and disasters.

The proposed strategy involves a Be Alert Game (BAG) piloted in small groups, with children ages seven to ten, in four countries in the Caribbean (Barbados, Grenada, Jamaica and the Republic of Trinidad and Tobago). Surveys were administered before and after the game was tested. The feedback from these surveys were used to determine learners' knowledge and approach before and after playing the game.

The game focuses on four natural hazards (hurricanes, tsunamis, earthquakes and volcanoes), their key features, preemptive and preparatory steps, and the potential impact of inaction. Gamers are encouraged to learn about natural events and disaster prevention by participating in interactive quizzes, drag-and-drop activities, researching and engaging with their teachers, family, and friends. The final component of each of the four levels in the game uses a blended approach and is mindful of the local context; thus, the location of the nearest emergency shelters will differ. Multimedia components include images, voice-over, music, sound effects, interactive buttons, animated characters and closed captioning. The developers will use the feedback from the participants to improve on the levels and interactive elements, which are all geared toward building resilience and preparing for natural hazards through game-based open learning.

Keywords: blended learning; disaster; game-based learning; natural hazard; resilience.

Using Game-based eLearning to Build Resilience to Natural Hazards in the Caribbean

The Caribbean region is faced with various natural hazards, some of which are seasonal such as hurricanes,¹ and others, such as earthquakes and volcanoes, are less predictable. Natural hazards may evolve into disasters based on the local context – the vulnerability of the population, level of awareness, preparatory steps, type of infrastructures and available resources. Due to the frequency and destructive² impact of natural hazards, organisations such as the Caribbean Disaster Emergency Management Agency (CDEMA) and The University of the West Indies Seismic Research Centre (UWISRC) provide information and training for local authorities, schools, agencies, communities, and stakeholders, to minimise the risk from hazards and disasters. CDEMA also assists with disaster relief and response and encourages adopting disaster loss reduction and mitigation policies and practices.

The region's administrators and teachers at the primary school level are guided by relevant approved curricula regarding hazard mitigation and are specific to grade levels; however, each grade level's focus differs by country. This paper and the eLearning game on which it is based are guided by but not limited to three curriculum documents for primary schools in 12 countries in the Caribbean and are as follows:

The Organisation of Eastern Caribbean States (OECS) Primary Social Studies Teachers' Guide (2006)

This document focuses on preparing for natural disasters that affect the Caribbean. The guide is part of the harmonisation project (shared curriculum) for regional cooperation in education with the OECS member states.³

OECS Primary Grades' Learning Standards for Social Studies (2018)

The Sustainability and Environment (SE) strand, sub-strand Weather and Consequences (WC), focuses on students being able to recognise the hurricane season, terms used to categorise the development of weather systems and the ability to describe the process of preparing for a storm. The learning outcomes for the earthquake and volcanoes (EV) sub-strand require students to describe how an earthquake and volcano is formed, the likely consequences on the lives of the people in the Caribbean, and to display personal responsibility for safeguarding themselves from the consequences of adverse weather conditions, earthquakes and volcanoes.

The Republic of Trinidad and Tobago Primary School Curriculum Guides for Standard 1 (2013)

This document focuses on developing a safety culture. Students are expected to explain what a hurricane, tsunami, and earthquake are, identify local agencies for disaster preparedness and management, demonstrate safety precautions, and give simple oral explanations for evacuation routes for home and school.

The three documents emphasize different hazards and areas of focus for specific grade levels, for instance, grade level one in the Republic of Trinidad and Tobago and grade level four within the OECS. However, according to a 2011 report on building resilience through education by the United Nations Children's Fund (UNICEF) and The United Nations International Strategy for Disaster Risk Reduction (UNISDR), children (of all levels) are among the most vulnerable to disasters caused by natural hazards. The impact of natural hazards could be reduced if appropriate, timely disaster risk reduction strategies are in place, and knowledge and education are key. The proposed eLearning game should complement the formal primary school curriculum (irrespective of grade level) or work as a standalone non-formal tool for preparing children to learn about natural hazards, the signs and how to respond before, during and after hazards.

¹ OCHA (2020): the Atlantic active storm season is from 1 June to 30 November. The Caribbean experienced an average of 17 hurricanes per year and 23 Category 5 hurricanes between 2000 and 2019. Along with Latin America, the Caribbean is the second most disaster-prone region globally.

² OCHA (2020): Intensity is not highlighted in this document, given that weak storms can be destructive; for instance, Tropical Storm Erika, with sustained winds of 50 mph, caused damage of US\$483 million (90% of GDP), although it passed well to the north of Dominica. Additionally, for the period 1990-2008 the Caribbean experienced an estimated US\$136 billion in damages from disasters (Association of Caribbean States, 2012).

³ OECS Members: Antigua and Barbuda, Commonwealth of Dominica, Grenada, Montserrat, St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Martinique and Guadeloupe.

A pre-test and post-test survey (Appendix 1 and 2) were carried out with players ages seven to ten; however, learners outside the target group were allowed to participate (ages 5, 6 and 12). The players were located in Barbados, Grenada, Jamaica and the Republic of Trinidad and Tobago. A reviewers' form (Appendix 3) was completed by adults in the education technology field from the countries mentioned above, excluding Grenada. The feedback from the parents/guardians were mainly to improve the learning experience. The data revealed that most learners surveyed were aware of two or three of the four hazards and knew what could be done if a disaster occurred. However, additional guidance is required, as was provided in the game for tsunamis and volcanoes. Moreover, given the focus areas in the curriculum guides compared to international practice, the game should also fill the gap and cater to learners in Grades 1 to 3 in the OECS and Jamaica. According to UNICEF and UNISDR (2011, p. 19), an important lesson learnt from worldwide disasters is that education, knowledge and innovation have the power to save lives by building a culture of safety and resilience at all levels and including learners ages 7-10, who are the future leaders and change agents.

Terminology Used

The definitions of the main concepts are in keeping with the explanations put forward by the United Nations Office for Disaster Risk Reduction (UNDRR) as adopted by the United Nations General Assembly on 2 February 2017. Resilience refers to the ability of a community exposed to hazards to resist, absorb and recover from the effects of a hazard in a timely and efficient manner. Hazards refer to a process or phenomenon that may cause injury or loss of life and damage to property. A hazardous event may lead to serious disruption at the community or national level and have severe human, material, economic and environmental losses. The four natural phenomena (hurricane, tsunami, earthquake, and volcano) mentioned in this document and the eLearning game are hazards. Through educational initiatives and mitigation strategies, hazards may not escalate into disasters if they do not adversely affect lives, livelihoods, and the environment. A disaster refers to a severe disruption of the functioning of a community due to hazardous events leading to one or more of the following: human, material, economic and environmental losses, and impacts.

The penultimate term is game-based learning (GBL). The eLearning game should be considered a GBL approach. It is a pedagogical tool focused on achieving specific learning outcomes (in keeping with regional curriculum guides) using an educational game (Anastasiadis, Lampropoulos & Siakas, 2018 as cited in Bates, 2019). GBL complements a blended approach to teaching and learning. Blended learning involves using traditional classroom teaching methods coupled with online learning (Garrison & Vaughan, 2008 as cited in Cleveland-Innes, 2018). Details regarding the game's blended approach are provided in the next section.

About the Game

According to Beiter (2017), games can reduce anxiety and increase student motivation to engage and learn beyond the classroom. Consequently, an eLearning game can be seen as a tool that teachers, parents, and guardians could use to introduce or bolster children's understanding of what steps should be taken before, during and after hazards have taken place. The Be Alert Game (BAG) uses six of the ten interface design principles as advocated by Blair-Early and Zender (2008) and visual design principles mentioned by Reyna et al., (2018, pp. 42-43) as follows:

- an obvious start and focus on the subject matter, i.e. hazards;
- web-safe fonts (sans serif font);
- sub-titles/closed captioning;
- blended media;
- layout consistency and repetition in the design;
- clear reverse and consistent logic (players may return to previous or move to the next slide, and progress is logical from level 1 to level 4);
- observes conventions (play, pause and replay buttons);
- feedback users receive immediate feedback on all knowledge checks; and
- an option to return to the 'Home/Help' scene is available throughout the game.

The BAG features a male and female character, as shown in Figure 1. The designers received preliminary feedback regarding the characters from a girl and boy (ages six and nine) who participated in the beta test and pre- and post-test surveys. They provided guidance regarding the characters' skin tone, hair colour and length, head size and clothing style.

Figure 1

Be Alert Game (BAG) Characters



The BAG has four levels, ranging from Level 1 Hurricanes to Level 4 Volcanoes (Figure 2). It includes text, audio, images, animation and closed captioning. Players may mouse-over or click each hazard button to hear a sound effect and select a character to listen to an introduction to the game. Each level begins with knowledge sharing, specifically, what is meant by each hazard, its features, the damages it may cause and the mitigation steps that should be taken. The knowledge sharing is via text, voice-over, music, sound effects and timed images. The final part of each knowledge sharing component is a list of keywords associated with a specific hazard and encouragement to players to find out more and communicate with their teacher, family and friends about what they've learned and the steps that should be taken. This research and collaboration activity is part of the game's blended approach to eLearning. Levels one to three include two knowledge checks in quizzes and drag and drop activities and level four includes a puzzle and maze.

Figure 2

Be Alert Game (BAG) screenshots of the game start, two knowledge checks and credits.



Benefits and Educational Implications

The anticipated benefits of the game include children's increased knowledge and awareness about natural hazards, leading to appropriate, timely action before, during and after a hazard (build resilience and ability to resist and recover). For instance, during an earthquake, remain outside (if outside) and away from anything that may fall. The multimedia components cater to those who prefer to read, watch, listen, participate, or combine media. The game has a regional focus and refers to hazards that affect the Caribbean and is guided by the curriculum documents used in twelve countries in the region. Learners may access the game via a weblink on a desktop or mobile device (no downloads or special device required). It may be stand-alone or be integrated into a learning management system and can include graded assessments and progression tracking. The game encourages a blended approach to teaching and learning at each of the four gaming levels. Players may also pause and replay sections and enable closed captioning.

Challenges and Limitations

The authoring tool used to develop the game has a modern and classic player. The modern player has a uniform, aesthetically pleasing appearance across devices (desktop and mobile); however, using this player results in a significant delay in the game's initial load time (17 seconds on the first attempt or after a new version of the game has been uploaded). The load time is reduced to 3 seconds from the second attempt onward. The frames for the animation were significantly reduced or removed to speed up the initial load time. Based on the feedback received from some of the participants, the developers may change the player to classic. Provided that the same gaming platform is used, revised versions of the game could be uploaded without affecting the learner's progress in the game, and they will have an option to resume playing from where they left off. The sample size of 15 (eight children and seven adults) was relatively small and one of convenience; thus, input from a larger group may lead to a more interactive game and improve the learners' experience.

Methodology and Results

The game review involved three e-forms: a pre-test, a post-test, and a reviewer form. Each form included reassurance regarding the anonymity of the data. The links to the forms were included in a cover message that provided background information regarding the game, the estimated time of completion, and the review duration (Appendix 1).

Pre-test Survey

The pre-test consisted of five close-ended questions and one open-ended question (Appendix 2). The ages of the respondents ranged from five to twelve. Four boys and four girls participated. They live in Barbados, Grenada, Jamaica and The Republic of Trinidad and Tobago. Before attempting the game, the majority of respondents could describe an earthquake and a volcano or an earthquake and a hurricane. Two could not describe a hurricane, and one could not describe a tsunami. It should be noted that two of the three respondents are ages five and six (younger than the target group). All of the respondents who completed the question regarding preparation indicated they know how to prepare for a hurricane (Figure 3). Fifty percent knew how to prepare for an earthquake, and none knew how to prepare for a tsunami (Figure 4). One parent completed the open-ended question and mentioned, "Responses are generally due to what is taught in school because of what occurs in the region. Greater awareness from a young age is definitely welcomed."

Figure 3



Pre-test survey responses to "I can describe the following hazards":

Figure 4





Post-test Survey

Six participants, ages six to twelve, completed the post-test survey (Appendix 5). After playing the game, all respondents could describe the four hazards. "Other" was listed an additional option after the fourth hazard and a respondent entered "blizzard" as their response. The nine-year-old and twelve-year-old knew what to do if any of the hazards occurred. The younger participants knew what to do in the case of a hurricane and volcano and hurricane and earthquake. Four girls and one boy (66.67%) of the participants selected Amy as their favourite character, and 50% suggested a dog as an additional character to choose from. Their favourite activity was the puzzle and maze (the Level 4 Volcano activities). All of the respondents could play the game unassisted (it should be noted that one of the six-year-old players did not respond to the question). Two Android tablets and four laptops were used. One of the laptop users pointed out that the game was slow to start and advance. A respondent stated, "The information is really informative and the graphics are great. It is a really fun game", and another stated, "the game is really really fun."

Figure 5





Figure 6



Post-test survey responses to "I know what to do to prepare for the following hazards":

Pre- and Post-test Surveys Comparison

The post-test survey results show a significant increase in knowledge regarding preparedness for tsunamis, earthquakes and volcanoes after learners played the Be Alert Game (see Table 1).

Table 1

Comparison of Pre-and Post-test Survey Results "I know what to do to prepare for the following natural hazards":

Hazard	Pre-test Survey	Post-test Survey	% Variation	Significant (S)/ Not Significant (N/S)
Hurricane	100	100	0	N/S
Tsunami	0	50	50	S
Earthquake	50	83.3	33.3	S
Volcano	16.7	66.7	50	S

The increased knowledge regarding tsunami preparedness could be considered very significant, given that none of the players knew how to prepare for a tsunami before playing the game.

Review

Seven adults completed the review form (Appendix 4). 57.1% were from the Republic of Trinidad and Tobago, 28.6% from Jamaica and 14.3% from Barbados. Responses were received from four women and three men, and their occupations were as follows:

Table 2

Reviewers' Occupations

Occupation	Percentage
Administrator	14.3
Consultant	14.3
Instructional Designer	14.3
Trainer	14.3
Technical Support	42.9

The aspects of the game that were considered most useful or valuable by reviewers are as follows:

- The descriptions of the disasters and the safety procedures that should be followed during the events.
- Easy navigation and clear learning instructions.
- The most valuable aspects were the sound effects, visuals and mini games.
- The questions related to what should be done during or after the disasters were most useful.
- The content is very child-friendly and the graphics are attractive.
- Audio and imagery.

The biggest challenges faced in playing the game identified by reviewers:

- Initially the items were slow to load.
- The biggest challenge was the lag time to start the game.
- The puzzle pieces should have a bigger "container" at the bottom to store them. They were somewhat "piled" on top of each other. This made it slightly more challenging to see which pieces to use. I enjoyed the game nonetheless.
- There were no challenges, however, a touch screen would be easier for younger children and so I would have them use a phone and tablet only (in the future).
- The maze.
- Understanding the objective. There was a lot of info they need to go away and ask about instead of being provided in the game.

The following were suggested by reviewers as ways the game could be improved:

- Make the character's speech more fluent. Make the maze more challenging. Add in-game links to descriptions of some of the terms used.
- Inset links to help with the investigation of the keywords.
- I would suggest when players input the wrong answer that they be provided feedback so that they can get the question right at the next turn. Also for the scenarios or other types of questions, when students select the wrong option they should 'face the consequences'. They should know what the resulting wrong choice could mean for their safety etc. I would also include the 'presence of uncertainty' in the game. For example, include variable difficulty levels, multiple-level goals, hidden information or an element of randomness to make the game more challenging.
- See comment at number 4 [i.e. the puzzle pieces should have a bigger "container"].
- The reward at the end of a task (clapping/ trophy) are very appropriate, perhaps have more games and a point system so they earn and redeem items.
- Add video.
- Earthquakes should also have an emergency kit. Clothing and meds are important to emphasize in the kit. Volcanoes had a diversity of activities that I was expecting to see throughout. The players weren't physically going through or walking anywhere or get any points, so the game aspect itself was limited. Maybe some kind of scoring or path to progress, mystery to solve and the different pieces of info are clues or something.

Five reviewers used a laptop, one used a desktop computer, and another used two devices (a tablet and laptop). The additional feedback and suggestions were as follows:

- NA
- Good job! Perhaps you can include speed as a factor in another iteration of the game. With natural disasters it is critical to act not only correctly but quickly. So adding the time element should assist players in making right choices in quick time in cases of emergency.
- The instructions said to click on the natural disaster to hear the sound it makes. However, I could also hear the sound when I "moused over" each icon. Maybe you should include this in the instructions.
- This is a great initiative, very informative. My children really enjoyed it. We look forward to the finished version which will undoubtedly be useful to educators and anyone else who interacts with children.

Recommendations and Conclusions

The developers can use the suggestions from the players and reviewers and upgrade the game before sharing it on a broader scale. Additionally, more interactive activities such as puzzles, and faster load time, for instance, as an app via Play Store will be investigated for the next iteration of the game. The developers will also highlight that the game could be further integrated into a learning management platform such as Moodle, and learner progress to higher levels could be linked to scores and speed of completion.

After the evaluation and review process, it was noted that The Republic of Trinidad and Tobago's Primary School Curriculum Guides Social Studies (2013) for Infants 1 and 2 includes basic safety precautions and drills about hurricanes and earthquakes. The document will be revisited and may have an input into the game's final version. Other potential upgrades in the game may include an option to allow players to select and name a pet to accompany them on their journey through each level, and downloadable offline access for players who have limited or no internet access. Enabling player customisation of characters is also under consideration.

Finally, although the respondents who could not describe some of the disasters were younger than the target group, the game developers are mindful that all children should be informed using child-friendly terminology of the different types of hazards that affect the region. OCHA (2020, p. 9) points out that while there have not been any disaster events directly caused by a tsunami in the Caribbean in the past two decades, the potential exposure remains high due to the vulnerability of the region to earthquakes and given that approximately 70% of the population reside or work in coastal areas. Vantage Point (2020) clearly articulates that children are the most vulnerable when disasters occur. Thus, helping children learn how to respond to natural hazards helps them gain a sense of understanding and control and equips them to respond more quickly and safely during crises. More work should be done, including obtaining feedback from a larger test group and experts in disaster mitigation in the region. Invitations to collaborate should be extended by the developers to teachers and trainers so that additional information, for instance, the location of emergency shelters unique to communities and countries could be included in the updated version of the game.

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Appendix 1

E-mail to Parents/Guardians/Teachers

Greetings,

You and your child/children (or learners in your care) ages 7 - 10 are invited to review the beta version of a free online game focused on **Using Game-based eLearning to Build Resilience to Natural Hazards**. Please note, children outside the target age range may also participate; however, ideally, they should be able to navigate the game with minimal assistance.

The game features four natural hazards (hurricanes, tsunamis, earthquakes, and volcanoes) and the pre-emptive and preparatory steps that should be taken. Gamers will learn about natural events and disaster prevention by participating in interactive quizzes, drag and drop activities, puzzles, and a maze and researching and engaging with their teachers, family, and friends. Multimedia components include images, voice-over, music, sound effects, closed captioning, interactive buttons, and animated characters.



- Estimated Time of Completion: 15-20 minutes
- **Duration of review**: 29th March to 5th April
- Game URL: <u>https://petalonline.moodlecloud.com/mod/scorm/view.php?id=140</u> or use the guest link at <u>https://petalonline.moodlecloud.com/</u>

We would need to measure the impact of the game and would be grateful if you could complete the following on behalf of the student:

- Before the Game: <u>https://forms.gle/6dJKUMKd3Rj9tji17</u>
- After the Game: <u>https://forms.gle/JJdKLMKSxgP2SDHa8</u>

If you would like to provide feedback as a parent/guardian/teacher or someone interested in game-based eLearning, then complete the following open-ended questionnaire after playing the game:

• **Review Form**: https://forms.gle/Vz7n4zNYUFZ5tfp78

As mentioned on each form, the data collected will be anonymized.

If you have any questions or encounter challenges accessing the game or the forms, you may contact me at <u>nicoleawelsh@hotmail.com</u> Please feel free to share this message and the links with anyone interested in learning about natural hazards and having fun while eLearning.

Appendix 2

Pre-test Survey: Before Playing the Game

Dear Parents/Guardians,

Thank you for allowing your child to play the Be Alert Game (BAG) focused on building resilience to natural hazards. Please note, the information collected in this form will be anonymised, therefore we will not be able to identify participants. If you have any questions regarding the game, please enter them in the final section of this form. You may enter the information on behalf of your child and include your e-mail address if you would like us to respond to your message.

*Required

1. I am _____ years old. *

o seven

o eight

- o nine
- o ten
- 0 other

2. I am a _____.*

o Boy

- o Girl
- Prefer not to say

3. I live in _____ [which country?]. *

- o Barbados
- o Grenada
- o Jamaica
- Republic of Trinidad and Tobago
- o Other

4. I can describe the following natural hazards:

- o Hurricane
- o Tsunami
- Earthquake
- o Volcano
- Other:

5. I know what to do to prepare for the following natural hazards:

- o Hurricane
- o Tsunami
- Earthquake
- o Volcano
- Other:

Additional Information (learners/parents/guardians may enter suggestions and expectations in this section)

Appendix 3

Post-test Survey: After Playing the Game

Dear Parents/Guardians:

Thanks again for allowing your child to play the Be Alert Game (BAG) focused on building resilience to natural hazards. We would love to hear from your child (you may enter the response on his/her behalf) on how we can improve the experience in the game!

Similar to the pre-test, the information collected in this form will be anonymised, therefore we will not be able to identify participants. If you have any questions regarding the game, please enter them in the final section of this form. You may include your e-mail address if you would like us to respond to your message.

* Required

1. I am _____ years old. *

- o seven
- eight
- o nine
- o ten
- Other:

2. I am a _____. *

- o Boy
- o Girl
- Prefer not to say

3. I live in _____ [which country?]. *

- o Barbados
- o Grenada
- o Jamaica
- Republic of Trinidad and Tobago
- Other:

4. I can describe the following natural hazards:

- o Hurricane
- o Tsunami
- o Earthquake
- o Volcano
- Other:

5. I know what to do to prepare for the following natural hazards:

- o Hurricane
- o Tsunami
- Earthquake
- o Volcano
- Other:

6. My favourite character in the game is:

- Amy 0
- Gavin 0
- Other: 0

7. If I could include a third character it would be a:

- Bird 0
- o Cat
- o Dog
- o Fish
- Other:

8. My favourite part(s) of the game is:

9. I learnt about the following from the game:

10. I did not like the following in the game:

11. I can play the game on my own

- 0 Yes
- No 0

12. I used a ______ to play the game.

- Android phone
- Android tablet
- o iPad
- iPhone
 Desktop computer (give details under other)
- Laptop (give details under other)
- Other:

Additional feedback (learners/parents/guardians may enter suggestions in this section)

Appendix 4

Reviewers' Feedback

Dear Parent/Guardian/Teacher/eLearner:

Thanks again for reviewing the Be Alert Game (BAG) focused on helping children build resilience to natural hazards. We would love to hear from you on how we can improve the experience in the game for the target group (ages 7-10).

The information collected in this form will be anonymised, therefore, we will not be able to identify participants. If you have any questions regarding the game, please enter them in the final section of this form. You may include your e-mail address if you would like a response to your message.

* Required

1. Country of residence? *

- Barbados
- o Grenada
- o Jamaica
- Republic of Trinidad and Tobago
- Other:

2. To which gender do you most identify? *

- o Man
- o Woman
- Prefer not to answer
- Other:

3. What is your occupation?

- o Administrator
- \circ Consultant
- Instructional Designer
- Learning and Development Specialist
- Teacher/Professor
- Technical Support
- o Trainer
- Other:

3. What aspects of the game were most useful or valuable?

4. What was the biggest challenge you faced in playing the game?

5. How would you improve the game?

6. What type of device did you use to play the game?

- Android phoneAndroid tablet
- o iPad
- o iPhone
- Desktop computer (give details under other)
 Laptop (give details under other)

Other:

7. Additional feedback and suggestions: