# Expanding Childhood Eyecare Education Through a Mobile Application


## Team Members

Timothy Esworthy

Jared Grimm

Annalise Robidoux

Griffin Roth

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## Advisors

Michael Aghajanian, Holly Ault

## Sponsor

Nune Yeghiazaryan Ph.D.,

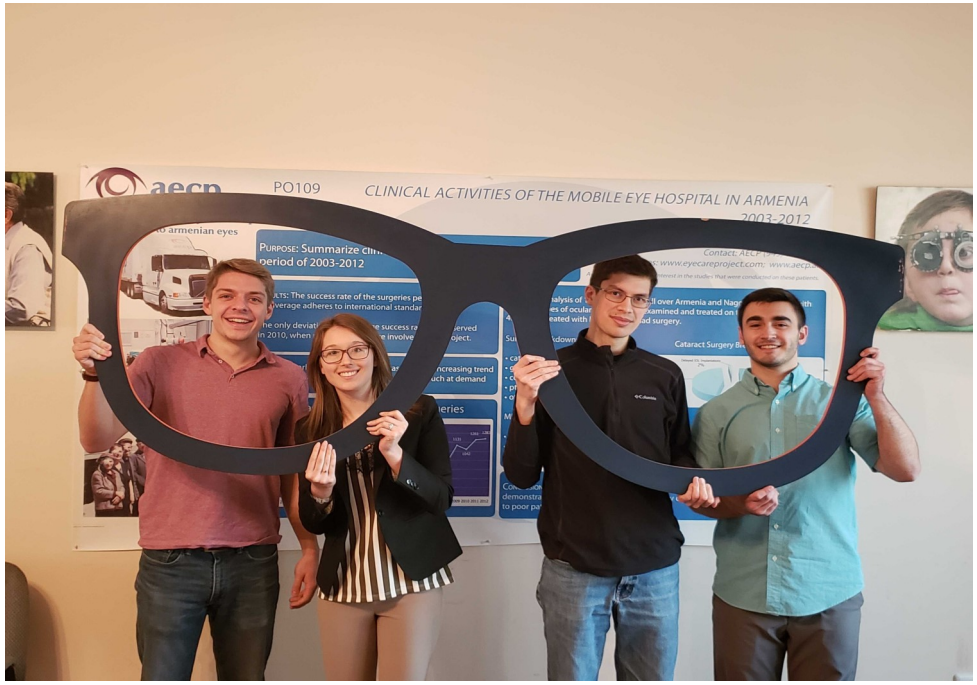
In-Country Director,

Armenia EyeCare Project



## Abstract

Education has the potential to reduce the high rates of preventable blindness in Armenia. The Armenian Eyecare Project (AECP) sought to expand childhood eyecare education through a digital supplement to their children's book *Desunik's Game of Sight.* Our team researched best practices for digital educational activities, designed mock-up videos and games, and tested the mock-ups in Armenian schools. Evaluation of activities for both educational value and enjoyability refined our recommendations on visual design, suggested activities, and transferable knowledge. We recommended developers and provided a prospectus fundraising package to produce the application. Our work will help educate and empower children to better care for their eyes, reducing preventable blindness in the future.



An Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science

**Figure 1: AECP Educational Efforts have been Brought to Children to Protect the Next Generation from Preventable Blindness**

## Providing Eyecare Education Through a Mobile Application

Public education is an important preventative measure in health care. Understanding self-care techniques benefits all aspects of personal health and hygiene. A study by Fries, Harrington, Edwards, Kent, & Richardson showed that when people are encouraged to practice self-management through public education, health risks decrease significantly[1]. Additionally, medical costs and doctor visits decreased as a result of subjects caring for themselves. Fries et al. showed that public education can substantially benefit all areas of health, including eyecare.

The Armenian EyeCare Project utilizes a variety of different programs to eliminate the vision impairments that affect 1 in every 20 Armenians[2]. These public education programs address their goal: "to change behaviors and attitudes about eyecare and to deliver information to all residents throughout Armenia"[3]. These programs decrease the risk of blindness by teaching self-management techniques and encouraging proper eyecare. The AECP's educational efforts include distribution of over 800,000 booklets, brochures, and workbooks aimed at children[3]. By focusing their educational efforts on children, the AECP hopes to reduce the rate of vision impairments of future generations. Current child education efforts are limited to a classroom setting for third graders. However, the AECP's new goal is to expand this education beyond the third grade to a broader age range with a mobile application.

There is currently no mobile app for eyecare education in Armenia. The *Desunik's Game of Sight* team recommended design plans for an interactive digital supplement to teach children 6-14 years old the basics of eyecare and eye health. While on site in Armenia, we built and tested mock-up activities and constructed a list of recommendations for the app. Additionally, we identified potential development studios for the app and created a prospectus marketing package to generate funding for development. The following eight objectives were identified and completed to address the AECP's goals for our project:

1. Identified games and activities that will build on the information from *Desunik's Game of Sight* to educate a broader audience with learning outcomes of eye structure, function, safety, and preventative care.
2. Identified best practice learning pedagogies for children.
3. Identified digital interactive activities that utilize learning pedagogies which have been proven to be effective in educating children.
4. Researched and identified successful design strategies and character designs that will hold the attention of students.
5. Researched and suggested development environments that will best accommodate the available android devices, desired features, and future updates.
6. Developed mock-up designs and sampled interactive games. Tested mock-ups with students for effective information retention, and engagement.
7. Assessed different cost and time estimates from developers the AECP recommended to implement the designs.
8. Developed a marketing package for the AECP to use when soliciting funding for the development of the app.

## Most Blindness is Unnecessary

Sight is such an integral part of everyday life that many believe losing their vision is equal to or worse than losing their memory, hearing, speech, or even a limb[4]. Visual impairment hinders daily activities of the affected person. For example, people who are visually impaired have a harder time finding employment. Those with extreme vision impairment experience unemployment rates as high as 36%[5]; almost seven times greater than the worldwide average of 5.3%[6].

Despite the consequences of blindness on everyday life, 80% of blindness worldwide is preventable or treatable[1]. In developing countries like Armenia, misconceptions about eyecare and overall eye health lead to an increase in preventable blindness. A study by Dr. Nairuhi Jrbashyan estimated that 5.5% of the Armenian population, over 160,000 individuals, are either visually impaired or blind[2] (Figure 2).

## The AECP's Mission is to Eliminate Preventable Blindness in Armenia

In 1992, Dr. Roger Ohanesian founded the Armenian EyeCare Project (AECP) to address the issue of preventable blindness. The AECP is a nonprofit organization that aims to provide the Armenian people with quality eyecare and education. The mission statement of the AECP is "to eliminate preventable blindness in Armenia and make 21st century eyecare accessible to every Armenian child and adult"[3]. In order to achieve this, the Armenian EyeCare Project provides medical care, public education, ophthalmologist education and training, screenings through their mobile eye hospital, and other services to multiple regions in Armenia (Figure 3). Dr. Jrbashyan concluded that cataracts are the most prevalent eye disease in Armenia. Macular degeneration, corneal diseases, diabetic retinopathy, and glaucoma also affect a significant amount of the adult Armenian population[2] (Figure 4). Of these diseases, many are treatable or preventable. In their efforts to prevent blindness, the AECP completed almost 10,000 cataract surgeries between 2003 and 2012[3].

Compared to other countries, Armenian children suffer higher rates of strabismus, glaucoma, diabetic retinopathy, retinal disorders, and inflammatory diseases[3]. Early identification

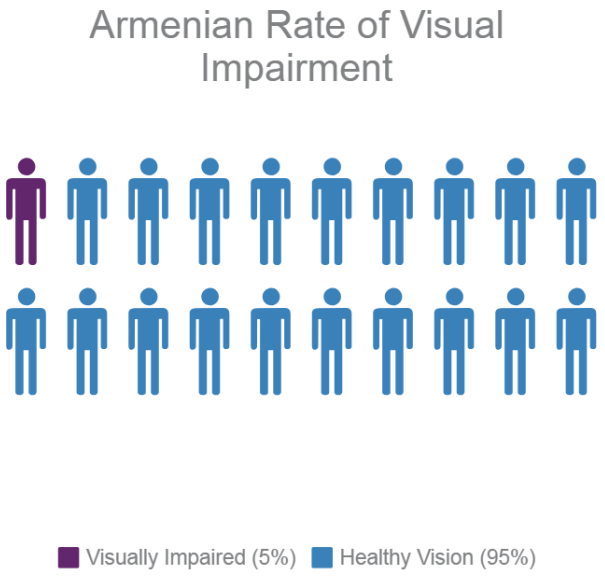



**Figure 2: Visual Impairment Rate in Armenia. Each character represents 150,000 Armenians.**


**Figure 3: AECP offices in Armenia**


**Figure 4: Percentage of Vision Impairment in Armenia**

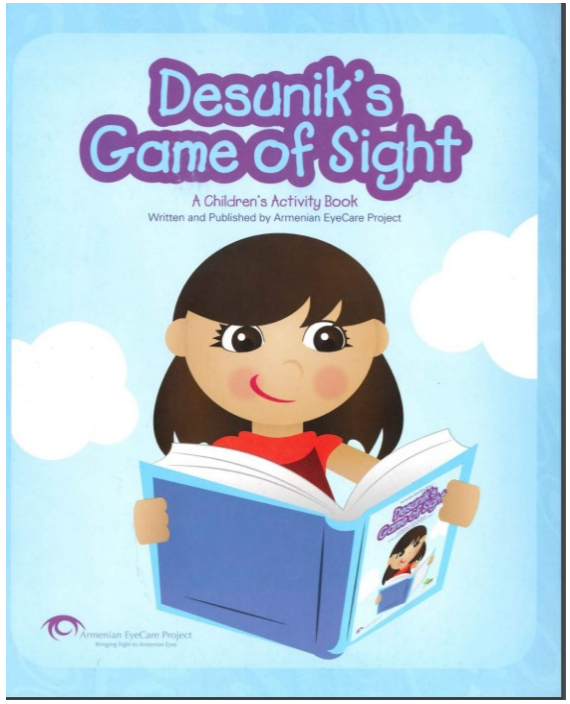



**Figure 5: *Desunik's Game of Sight***

and treatment of such diseases is especially crucial in children considering 50% of learning disabilities are vision related[3]. For example, strabismus, commonly known as lazy eye, can greatly hinder a student's reading and tracking capabilities. The AECP provides children with early intervention screenings both in schools and through their mobile eye hospital.

## The AECP Launched a Successful Eyecare Education Program for Armenian Children

Although screenings are effective, the AECP also educates children on eyecare as a preventative measure. One educational tactic the AECP utilizes is *Desunik's Game of Sight*: an interactive educational book for third grade students (Figure 5). The AECP distributed the book and lesson plans with the hope that students, "will have the knowledge to care for their own eyes and feel encouraged to share that knowledge with their family and friends in order to improve eye health across Armenia"[7]. The book and lesson plans are distributed to schools for free and taught in a classroom setting. Students complete hands-on activities during the lessons, making the learning experience interactive and engaging. The book features fun, educational lessons on anatomy, function, safety, and care of the eye. The AECP believes the book is effective at educating children on eyecare and the Ministry of Education and Science endorsed the book for use in extracurricular school classes[3].

Due to the success of the book, a supplementary board game is currently in development. The game repeats information that is featured in the book and also includes new information through unique activities. Unfortunately, both the book and board game are only distributed to classrooms with limited age ranges. The AECP wishes to expand its audience by creating a mobile application.

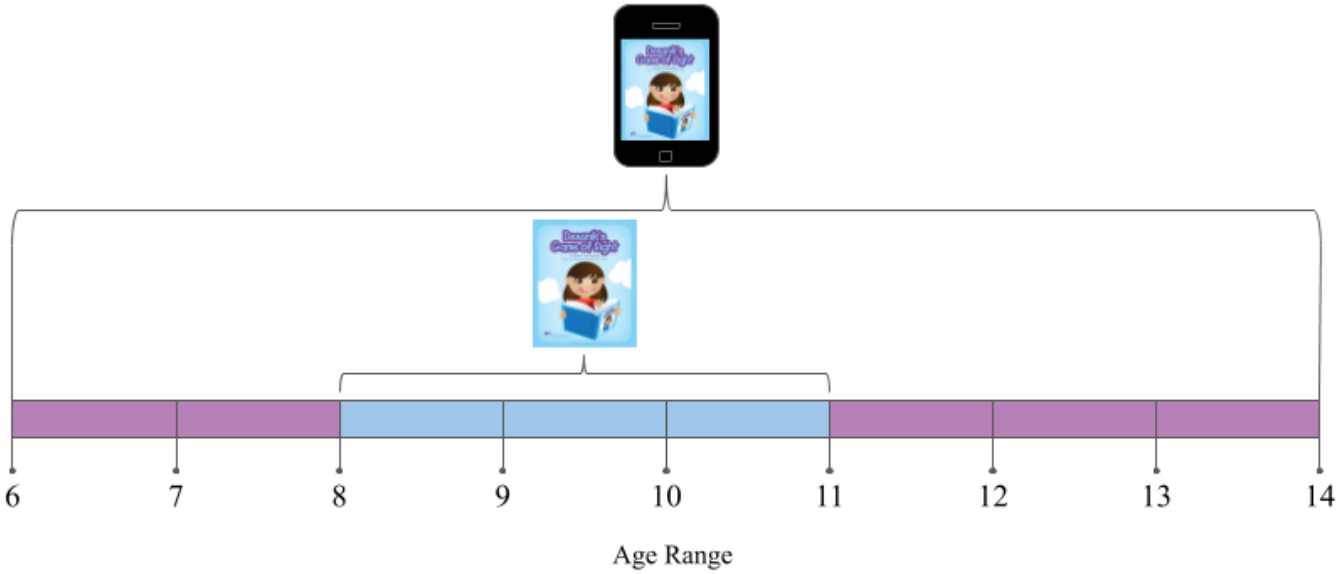



**Figure 6: Coverage of Age Range Comparison Between Book and Mobile App**

## AECP Wants to Leverage Mobile Apps for Eyecare Education

While the book is successful, each book can only be used once by a student and the book's audience is limited to children ages 8 to 11. The AECP must print more copies each year, which can become costly. According to UNESCO, 152,970 Armenian students aged 8 to 11 were enrolled in primary school as of 2017[8]. It would cost the AECP over $200,000 to print enough books for all Armenian 3rd graders each year. While the information in the book is limited to younger audiences, mobile activities have the flexibility to accommodate a wider range of students (Figure 6). Additionally, the AECP has not been able to send copies to every school in Armenia. A mobile application will expand the audience beyond the AECP's current reach. Also, a mobile app can be accessible all over the world to a larger age range, both in and outside of classrooms. Additionally, development is a one-time cost because the app can be downloaded infinitely at no expense to users, making it cheaper than the book in the long term.

## Mobile Apps are Effective Education Tools for Children

In a 2009 study, Cheung and Hew concluded that mobile apps are effective education tools for children[9]. In their study, they reviewed 44 scholarly articles and found that students using mobile devices outperformed their peers who used conventional paper guide books[9]. Mobile learning, also known as M-Learning, integrates active learning with mobile devices to provide more engaging lessons. Kearney, Schuck, Burden, & Aubusson determined that M-Learning allows students to learn anytime, anywhere, while progressing at their own pace[10].

## Educational Pedagogies Tailor Apps to the Circumstances in Which They Will Be Used

Educational pedagogies explain how learning takes place and how the students and teachers will interact. These pedagogies are used to understand how children learn best in different settings and can maximize the learning potential of mobile apps. Wall, Litjens & Taguma found that high quality early childhood education and care offers immense opportunities for all children to develop the cognitive and social and emotional skills needed for success in later life[11]. Incorporating a formal educational pedagogy into a mobile application enhances the learning outcomes.

Many learning techniques have been applied to educational games to further engage students in active learning[12]. Games teach students in a way that allows for more interaction with the material and each other. Presenting material usually found boring to students through an interactive activity invokes a student's eagerness to learn. Technological advances allow many activities to be made into mobile apps which make the learning process much more engaging.

An important factor to consider in educational app development is a phenomenon known as the pass-back effect. This is when "an adult, usually a family member, allows a young child to play with his or her smart mobile device". Each pass-back session typically lasts between 5 and 20 minutes[13]. Access to these educational games is therefore constrained by time and parental allowance. With this in mind, activities so should be designed so that children can complete them in a short amount of time.

## AECP Will Need to Raise Funds to Pay for App Development

According to Charity Navigator, the AECP receives over 95% of its revenue from donor and grant contributions[14]. Sources of funding will need to be identified to enable the AECP to contract the development of this app. The majority of non-profit funding in Armenia originates from over 7 million Armenians who live in diaspora or dispersion in other countries[15] (Figure 7). Due to this, it is important to target diaspora members to maximize the reach of a funding campaign.

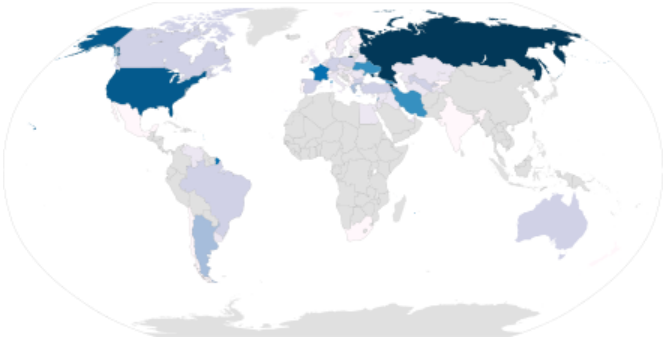


**Figure 7: Armenian Diaspora Concentrations**

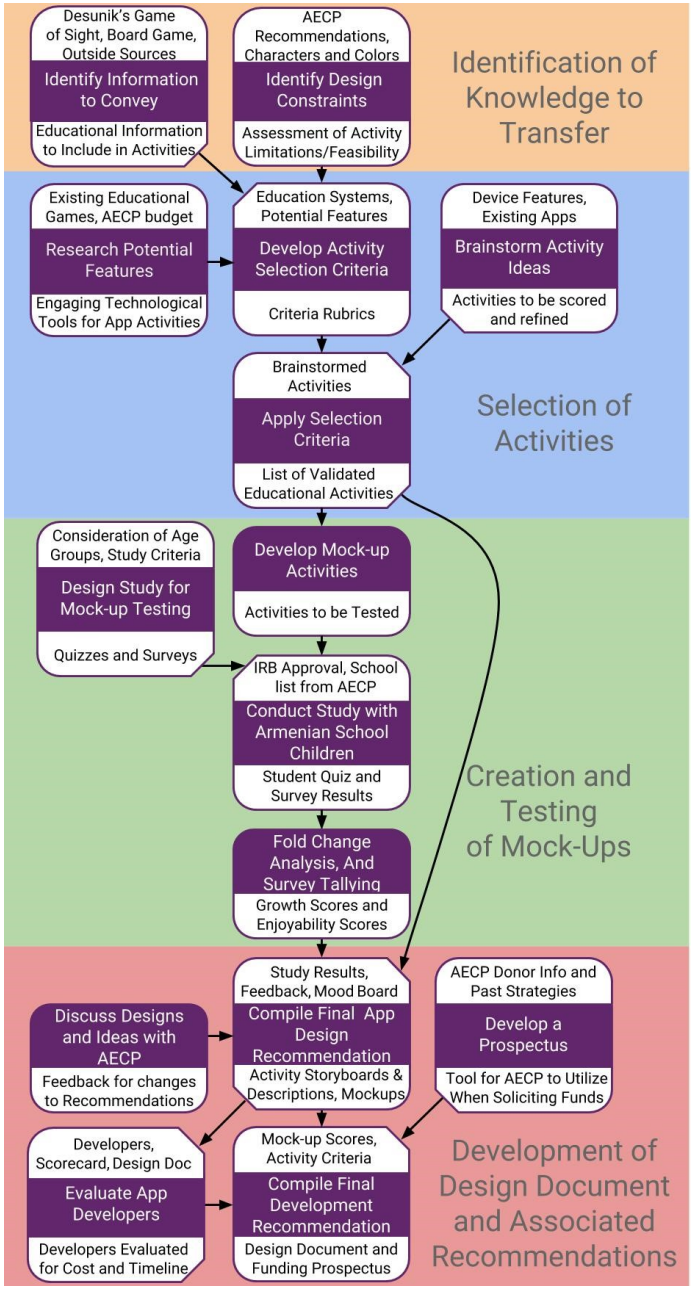



**Figure 8: Block Diagram**

## This Project Aims to Make Recommendations for a Digital Supplement to *Desunik's Game of Sight*

The goal of the project was to propose design plans for an interactive digital supplement to *Desunik's Game of Sight.* The proposed mobile app presents the information found in the original book and additional lessons in the form of interactive activities for varying age groups. We created a detailed design plan which included recommended activities and technologies to provide guidelines to address the needs of children in Armenia. Our app needed to be effective enough to justify diverting funds from printing more of the already successful book. Upon its completion, the mobile application will be free for users and easily distributed across the country. It will allow children of a broader age range to learn at any time and extend the learning environment outside the classroom, creating an opportunity for independent learning. Later on, it can be translated into different languages enabling international use. If successful, this application can be used as a model for educational apps from other fields of health care.

## The Project Utilized a Four Stage Approach

The stages are as follows (Figure 8):

- Identification of knowledge to transfer
- Selection of activities
- Creation and testing of mock-ups
- Development of design document and associated recommendation

In order to determine the scope of the activities included in the app, a comprehensive list of information to be included needed to be identified. Through meetings with AECP staff and independent research, we identified topics that would best supplement the book. We compiled information from the sources provided by the AECP in order to maximize the learning potential of the lessons for users. Once we identified the knowledge to be transferred, we brainstormed activities that would portray the knowledge in fun and engaging ways. To objectively review our ideas, we developed evaluation criteria to refine our thinking and ensure that all recommended games were educational and engaging. To reinforce our criteria, we tested a few of the activities with students using a mock-up version of the application. Through surveys and observations of children playing the games, we were able to generate data on both the enjoyability and educational value of the activities. This set of data let us refine our activities to provide more robust recommendation for the AECP. In the end, we produced a formal app design document, evaluated potential development studios, and constructed a marketing prospectus for solicitation of funds.

## Sources of Information Were Combined to Identify Knowledge to Transfer

The knowledge to transfer built upon the information included in *Desunik's Game of Sight.* Lessons on parts of the eye, how the eye works, eye safety, and eye health and care were recommended for inclusion in the application

(Supplement 1). We compiled information from *Desunik's Game of Sight,* the AECP board game, and outside sources (Figure 9). To ensure the app would be engaging, the information needed to be presented in a novel and interactive way by leveraging available technologies.

To accommodate the broader audience desired by the AECP, the levels were split into three age ranges (ages 6 to 8, ages 9 to 11, and ages 12 to 14). To keep the older groups interested, lessons were made more comprehensive by including information on depth perception, convergence, and color blindness, and how various diseases arise and affect vision. Different eye diseases were incorporated for students age 12 to 14. Refractive errors and conjunctivitis were included in the lesson plans for students age 9 to 14, since they are more common in children.

This information was compiled into three separate lists, one for each age group (Supplement 1). We reviewed all of the information in meetings with the AECP medical staff to confirm its accuracy and relevancy to each age group.

**Knowldege To Transfer**

| Topic | Source | | | |
|---|---|---|---|---|
| | *Desunik's Game of Sight* Book | *Desunik's Game of Sight* Board Game | AECP Medical Staff | Research |
| Eye Health | ✓ | | ✓ | |
| Eye Anatomy | ✓ | | ✓ | |
| Eye Function | ✓ | | ✓ | ✓ |
| Eye Safety | ✓ | | ✓ | ✓ |
| Eye Diseases | | ✓ | ✓ | ✓ |

**Figure 9: Sources of Knowledge to Transfer**

## Evaluation Criteria Identified Educational and Enjoyable Activities

Once we finalized our knowledge to transfer, we brainstormed activities (Supplement 2) and established criteria to evaluate their effectiveness at teaching the information in an engaging way (Supplement 3). We continued the brainstorming process to ensure all of the knowledge to transfer was included. Our brainstorming resulted in eleven different activities collectively covering all knowledge to transfer, which we then evaluated using our evaluation criteria. Four activities passed the evaluation criteria and were chosen for the mock-up. They were "Colorblind Maze," "Protect the Eye," "Assemble the Eye," and "Search and Find."

"Colorblind Maze" is an activity with a constantly moving path. Students will have to keep Desunik on the correct path using the touchscreen. The colors of this activity will reflect those of a color blindness screening chart.

In the activity "Assemble the Eye," students will be tasked with putting all of the parts of Desunik's eyes in the right place so she can see. The correct completion of the eye will allow Desunik to see a hidden picture. This picture can be randomly selected based on a set of pictures designed for each age group. As the students assemble the eye, light rays will begin to enter the eye and will be adjusted due to the function of an added part. For example, if the students place the cornea in the correct location, light enters but as a wide blur. If the students then place an iris, which contains the pupil, the blur of light is narrowed into a smaller cone. When the lens is correctly placed, the light focuses onto a specific location. When the retina is placed at the back of the eye the hidden image will be shown to students.

The activity "Protect the Eye" tasks students with placing the lids, lashes, and brows in the correct location to start the game. Then they must swipe and hit away dirt before it reaches Desunik's eyes. If some does reach Desunik's eye, it will get red and the screen will darken. They must then use their finger to move the eye lids up and down to simulate blinking and flushing out the dirt in a safe manner. After three eye irritations, the level ends.

"Search and Find" is a game where the students are tasked with finding objects in a picture that correspond with a prompted question. For example, they may be asked to find all the things that are healthy for your eyes. With different pictures, objects, and difficulties, this game can be replayed many times to reinforce which objects are helpful or harmful to your vision.

When developing our criteria, we kept

four questions in mind:

- Is the proposed activity enjoyable for children age 6 to 14?
- Does the proposed activity transfer the knowledge of one of the learning objectives?
- Does the proposed activity utilize technology in a fun and engaging way?
- Does the proposed activity cost fit the AECP budget?

To ensure that the activities in the app were engaging and fun, we conducted research on what makes a children's app popular. Research by Harnil Oza suggests that children enjoy apps with sound effects, bright colors, and a concrete point system that fosters competition[16]. These elements were taken into consideration during activity selection through the creation and use of an enjoyability checklist. The checklist ranked activities higher if they incorporated these features. Activities that have at least four of the elements were considered sufficiently enjoyable. Activities that have similar gameplay to popular apps in Armenia were also considered to be enjoyable based on their established success among children.

Our criteria determined "Eyelash Dash," "Colorblind Maze," "Assemble the Eye", "Protect the Eye," "Search and Find" and other activities to be enjoyable from our brainstormed list of activities (Supplement 3). These four activities feature all of the enjoyability elements of sound effects, bright colors, and point systems (Figure 10). "Colorblind Maze" can be adapted to different difficulties as the game progresses making it more enjoyable for older students.

To ensure that activities effectively taught the information, educational criteria were developed. These criteria were derived from two studies[16,17]. The studies evaluated the educational potential of mobile applications and analyzed the pedagogies involved with mobile learning. By synthesizing the findings of these two studies, we created a scorecard in order to determine how each activity includes the educational criteria (Figure 13). The scorecard is separated into three categories: must have, should have, and want to have (Figure 11). The "must have" criteria included an educational pedagogy approach,

| Activity | Elements of Enjoyability | | | | |
|---|---|---|---|---|---|
| | Sound Effects | Bright Colors | Point System | Varying Difficulty | Popular Gameplay |
| Assemble The Eye | ✓ | ✓ | ✓ | ✓ | |
| Protect The Eyes | ✓ | ✓ | ✓ | ✓ | |
| Colorblind Maze | ✓ | ✓ | ✓ | ✓ | |
| Search and Find | ✓ | ✓ | ✓ | | ✓ |

**Figure 10: Enjoyability Checklist to Evaluate Activities**

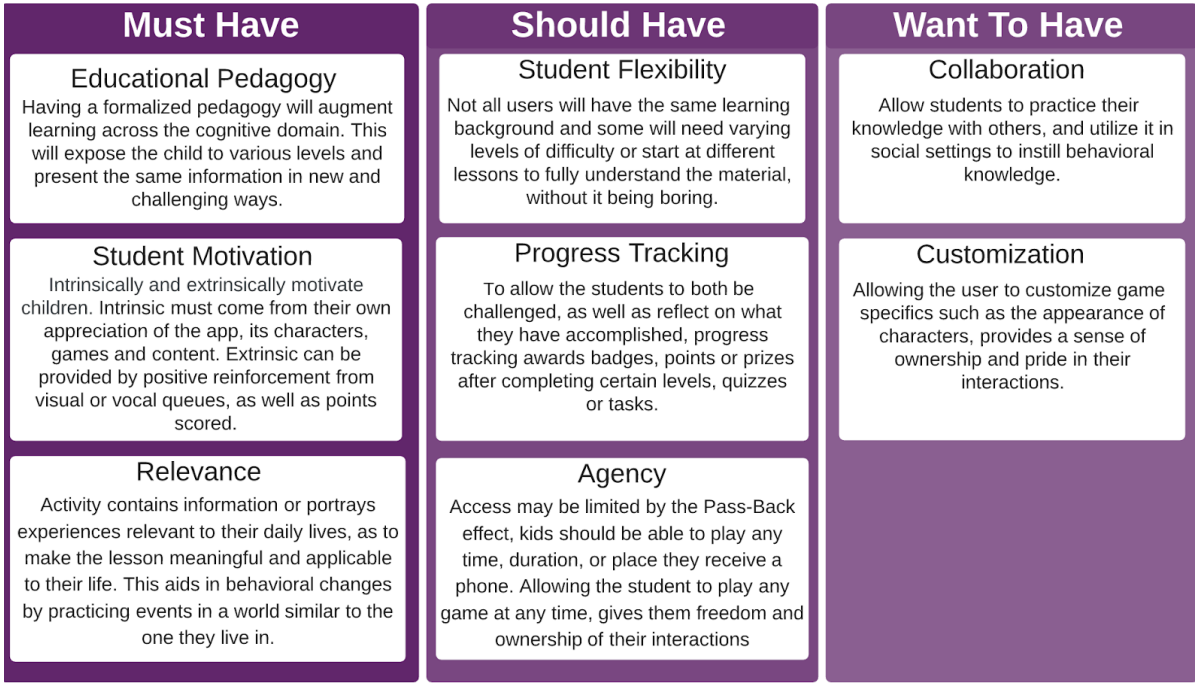



**Figure 11: Educational Criteria Descriptions and Ranking**

| | |
|---|---|
| Create<br>Combine | Producing an original product or an easily understood result by bringing components together. |
| Evaluate<br>Rank | Making decisions, checking, or criticizing ideas based on the standards or criterions. |
| Analyze<br>Order | Dividing materials into components and then organizing the relationships between components |
| Apply<br>Classify | Using, implementing, or applying appropriate methods to a given situation. |
| Understand<br>Sumarize | Explaining the meaning of messages that contain communication forms of speaking, writing and graphics. |
| Remember<br>List | Identifying, recalling or bringing to mind relevant information from long-term memory. |

**Figure 12: Bloom's Taxonomy and Related Goal Activities**

| Criteria | Description of Use | Quality of Criteria Use | | |
|---|---|---|---|---|
| | | Low | Medium | High |
| **Must Have** | | | | |
| Educational Pedagogy | Combine: students will have to recreate the anatomy of the eye to make it functional, by combining parts to see how an image is formed | | | X |
| Student Motivation | Sounds rewarding correct placement, feedback from Desunik, and the motivation to reveal the hidden picture / improve score | | | X |
| Relevance | Makes an eye to see an image of something they are familiar with such as famous buildings in Armenia or superheroes for younger students | | | X |
| **Should Have** | | | | |
| Progress Tracking | A Badge can be awarded when they successfully assemble an eye | | X | |
| Student Flexibility | Can be customized for each age group to have more or less parts to add | | X | |
| Agency | Very short game they can complete in a small time with a phone | | | X |
| **Want to Have** | | | | |
| *Colaboration* | Compete with friends for better time | | X | |
| *Customization* | They can experiment by placing eye parts in different places. However, only the correct configuration will be accepted | X | | |

**Figure 13: Example Scorecard: Assemble the Eye**

motivation for the student to continue, and relevance to the students' lives. In order for an activity to be considered, it needed to meet all "must have" criteria. The "must have" criteria ensured that the activity leveraged cognitive growth, retention of information, behavioral changes, and continued learning. The remaining criteria increased the learning outcomes and were included whenever possible. The "should have" criteria included progress tracking, student flexibility, and agency. The "want to have" criteria included collaboration with other students and customization of the game.

One of the "must have" criteria is an educational pedagogy. To satisfy this, we utilized Bloom's taxonomy to analyze the educational value of each activity. Bloom's taxonomy is a learning pedagogy developed by Benjamin Bloom, to address different levels of learning. Bloom identified three domains of learning activities: cognitive, affective, and psychomotor[10]. The cognitive domain encompasses thinking, logic, and reasoning; which focuses on information retention. Next, the affective domain involves feelings, motivations, and attitudes to encourage behavioral changes. Finally, the psychomotor domain involves understanding physical dynamic movements and interactive causes and effects of the real world[11]. Combinations of these three domains can be applied when designing mobile application activities. By utilizing the goal activities from Figure 12, diverse types of learning are fostered by addressing a broad range of student abilities. Using activities that incorporate higher levels of Bloom's Taxonomy provide new ways of thinking for children[11]. Each activity was placed in a level of Bloom's taxonomy based on whether the activity had them combine, rank, order, classify, summarize, or list information (Figure 12).

The five activities mentioned above also fulfilled our educational criteria scorecard (Supplement 4). For example, "Assemble the Eye" satisfied all of the "must have" criteria (Figure 13). In the activity, an educational pedagogy was utilized by allowing children to combine information on both the parts and the functions of the eye. They were also able to recreate the image of the eye. We determined that the mystery from unveiling a picture will give children the proper motivation to continue the game. The game will be relevant to a student's life by unveiling pictures that are centered around Armenian life. In addition to satisfying the "must have" criteria, "Assemble the Eye" also satisfied all of the "should have" criteria.

It was also important to stay within the budget defined by the AECP, so we made sure that all potential functions and features of the app would stay within their desired budget of $10,000. We researched features and functions that are typically included in gaming apps and could potentially see use in our app. Then we constructed a list of all the technologies, how much each cost, and how long it would take to develop each one (Supplement 5). From there, we determined which technologies the AECP could afford and only chose activities for the minimum viable product that would utilize these technologies. For example, technologies such as virtual reality or augmented reality were significantly outside the budget of the AECP. Virtual reality itself can cost up to $8,000 and take approximately 6 months to develop, stretching the timeline of the project. However, a gyroscope and accelerometer, which cost about $1,000 each to incorporate, are within the budget. If a feature would have significant benefit to the app, but is currently not affordable for the AECP, it was recommended for future iterations of the game.

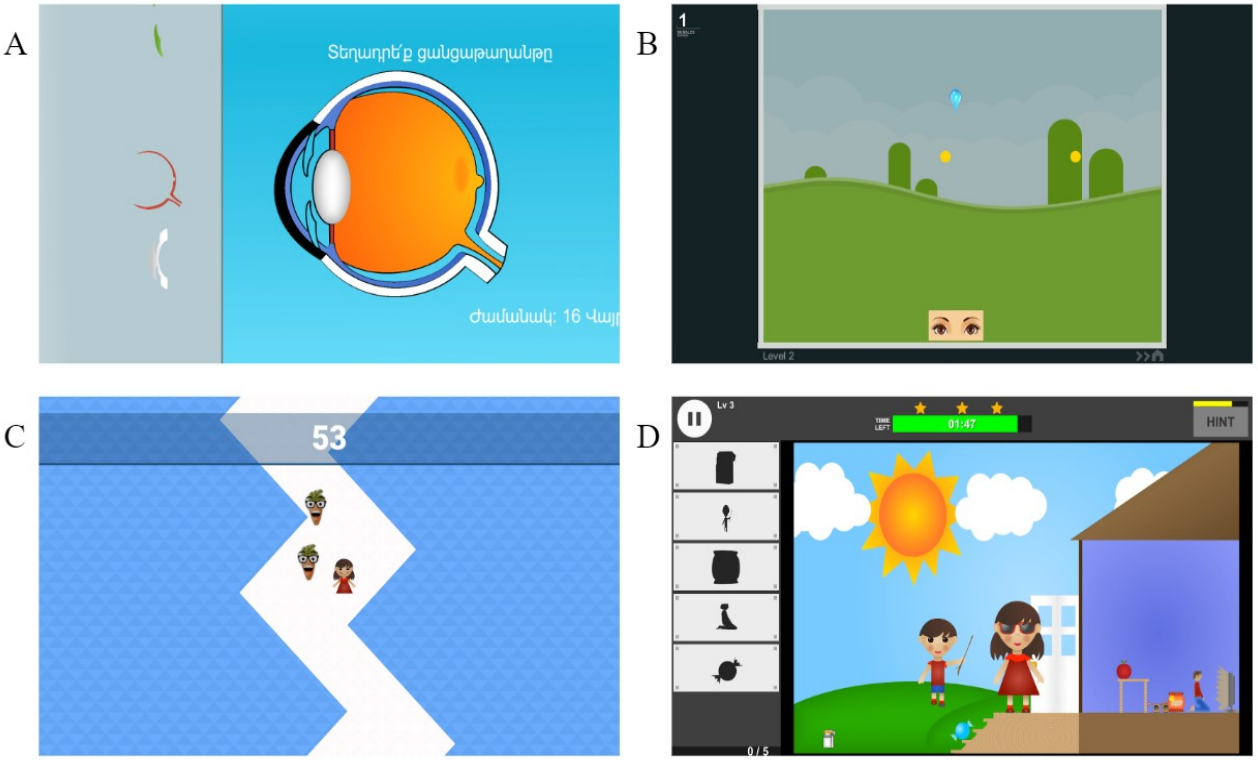



**Figure 14: Example Screens for Games: A) Assemble the Eye B) Protect the Eye C) Colorblind Maze D) Search and Find**

## Mock-up Activities Were Tested for Enjoyability and Educational Value

From our generated list of information and potential games to be included in the final app, we created mock-up activities to test in schools around Yerevan. Because most schools did not have mobile devices for us to conduct the tests on, we made the mock-up for the computer so the tests could be conducted in their computer labs. Due to time constraints, only four recommended games were constructed: "Search and Find," "Assemble the Eye," "Protect the Eye," and "Colorblind Maze" (Figure 14). We decided to include these games in the mock-up to represent a balance between slower, more educational games, and fun fast-paced games. "Search and Find" and "Assemble the Eye" are considered to be educationally valuable. "Colorblind Maze" and "Protect the Eye" do not teach as much, but are fast-paced and enjoyable. These games were within our coding ability, whereas the other games were too complex.

Although these games were originally brainstormed for a mobile device, they were adapted to suit a computer platform. Instead of dragging a finger on the screen, clicking was used to change the direction of Desunik for the "Colorblind Maze". Similarly, in the "Protect the Eye" game, students could not use a touchscreen to swipe dirt away from the eyes on a computer.

Instead we, programed the game to wash the dirt away by aiming tears at dirt particles. Despite the adaptation of the mock-up for computers, the final version of the app will still be for mobile devices.

We constructed the games utilizing the Unity Game Engine. Unity uses the C# scripting language alongside a drag-and-drop development environment. Unity is a well-documented engine with many tutorials available online, which made it much easier to learn and use. Additionally, we could efficiently generate games using built-in libraries for physics and collision detection. Our games were demonstrated to our advisors and AECP staff, then revised based on their feedback. Upon final approval, English text in the games was translated and replaced with Armenian.

We integrated educational videos for the students to watch before they played the games (Figure 15). These videos featured Desunik talking students through different lessons on the eye. We created three different scripts based on the lists of knowledge to transfer for each age group. The script was translated into Armenian and a staff member from the AECP recorded audio files for Desunik's dialogue (Figure 16). The games and videos were combined into a single package to test in schools.

To evaluate the mock-up, we used a progress evaluation quiz (Supplement 6) and an enjoyability questionnaire (Supplement 7) which were reviewed and translated by staff at the AECP. During the school visits, we administered the quiz before the students played with the mock -up. After they played, we had the students fill out the post-quiz and enjoyability questionnaire. We tested the mock-up with students from three age groups: 6 to 8, 9 to 11, and 12 to 14. At each school, four to six students from each of the age groups were allowed to play with the mock-up. We were given only 45 minutes with each of the groups, so we limited the amount of information taught in the activities. Additionally, we carefully planned our time with each group. We allocated 25 minutes for using the app to allow time for the pre-quiz, post-quizzes and questionnaire.

We made different quizzes for the three age groups to reflect their lessons (Figure 17). Each quiz consisted of a true or false section and an eye labeling section. The youngest age group had to label the outer parts of the eye and were given a simpler diagram than the older students, who were taught inner eye anatomy. During school visits we met with 9 boys and 9 girls in the 6 to 8 age group, 7 boys and 11 girls in the 9 to 11 age group, and 3 boys and 13 girls from the 12 to 14 age group, for a total of 52 students. After the school visits, we compared the pre-quiz to the post-quiz scores to understand how much each student learned (Supplement 8).

The progress evaluations showed positive results across all three age ranges. Six students in the 6 to 8 age range and 6 students from the 9 to


**Figure 15: Video Lesson Example Slide**

**Figure 16: Students Watching Prepared Videos**

**Figure 17: Students Taking Quizzes and Playing with Mock-Up**

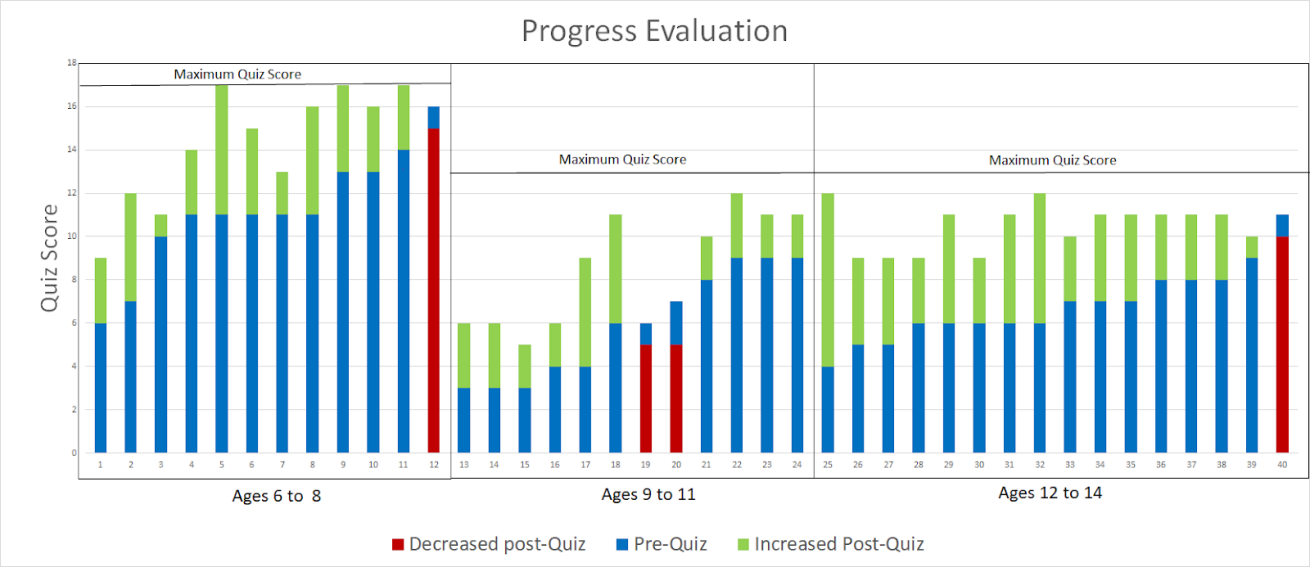
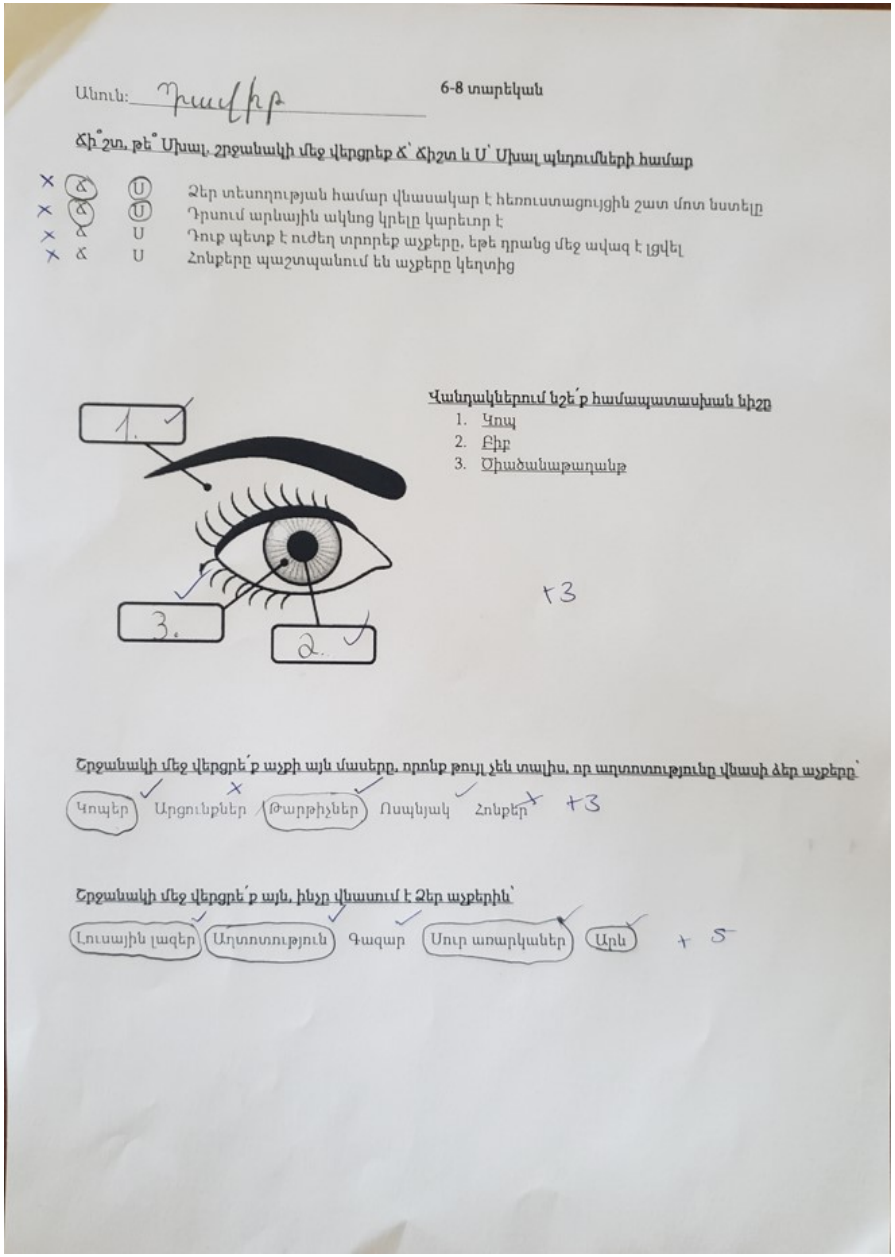



**Figure 18: Progress Evaluation Results**

11 age range were not included in our final results as their tests were revised for later groups. Across all three age ranges, a majority of students correctly answered the true and false questions, which resulted in high pre-quiz scores . Because of this, their potential for growth on the post-quiz was limited. The 12 to 14 age range saw the largest improvement with a 67.8% increase in scores. The 6 to 8 and 9 to 11 age groups showed 31.9% and 35.2% increase respectively (Figure 18). We believe the larger growth in the 12 to 14 age group can be attributed to their developmental state. According to the Child Development Institute, a child gains increased memory and the ability to think abstractly around 12 to 13 years old[18]. This leads us to believe that the eldest age group was able to retain the information easier than the other two by drawing connections between the information. The younger two age groups may require more reinforcement of the information to reach the same level of growth as the 12 to 14 year olds. Four students had post-quiz scores either the same as or lower than their pre-quiz scores. (Figure 18). This may mean that there was a flaw in the test. It is possible that the students learned information that had not been represented on the quiz, and therefore could not display their increase in knowledge.

In the enjoyment questionnaires, students in the 6 to 8 year old age group had two different answers to choose from: agree or disagree. The students aged 9 to 14 had four answers to choose from: strongly agree, agree, disagree, and strongly disagree. These answers were represented by facial expressions to avoid confusion during translation into Armenian. The questionnaire was administered to the students after the post-quiz. They were given approximately 2 minutes to complete the questionnaire.



Անուն: Դավիթ

6-8 տարեկան

Ճի՞շտ, թե՞ Սխալ. շրջանակի մեջ վերցրեք Ճ՝ Ճիշտ և Ս՝ Սխալ պնդումների համար

| | | | |
|---|---|---|---|
| ✗ | Ճ | Ս | Ձեր տեսողության համար վնասակար է հեռուստացույցին շատ մոտ նստելը |
| ✗ | Ճ | Ս | Դրսում արևային ակնոց կրելը կարեւոր է |
| ✗ | Ճ | Ս | Դուք պետք է ուժեղ տրորեք աչքերը, եթե դրանց մեջ ավազ է լցվել |
| ✗ | Ճ | Ս | Հոնքերը պաշտպանում են աչքերը կեղտից |

Վանդակներում նշե՛ք համապատասխան նիշը

1. Կոպ
2. Բիբ
3. Ծիածանաթաղանթ



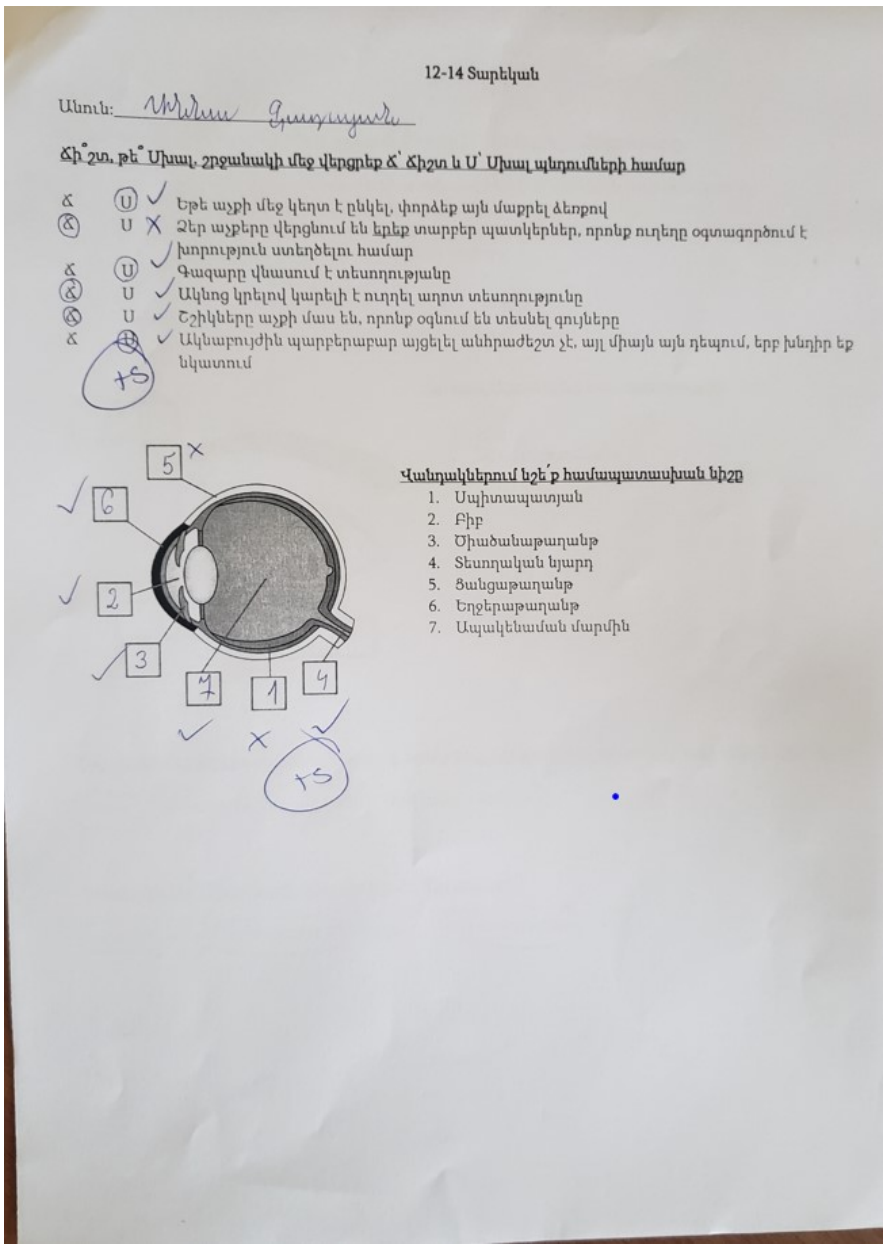

+3

Շրջանակի մեջ վերցրե՛ք աչքի այն մասերը, որոնք թույլ չեն տալիս, որ աղտոտությունը վնասի ձեր աչքերը՝

Կոպեր ✓ Արցունքներ ✗ Թարթիչներ ✓ Ոսպնյակ ✓ Հոնքեր ✗ +3

Շրջանակի մեջ վերցրե՛ք այն, ինչը վնասում է Ձեր աչքերին՝

Լուսային լազեր ✓ Աղտոտություն ✓ Գազար ✓ Սուր առարկաներ ✓ Արև ✓ + 5



12-14 Տարեկան

Անուն: Մհեր Գրիգորյան

Ճի՞շտ, թե՞ Սխալ. շրջանակի մեջ վերցրեք Ճ՝ Ճիշտ և Ս՝ Սխալ պնդումների համար

| | | | |
|---|---|---|---|
| Ճ | Ս | ✓ | Եթե աչքի մեջ կեղտ է ընկել, փորձեք այն մաքրել ձեռքով |
| Ճ | Ս | ✗ | Ձեր աչքերը վերցնում են երեք տարբեր պատկերներ, որոնք ուղեղը օգտագործում է խորություն ստեղծելու համար |
| Ճ | Ս | ✓ | Գազարը վնասում է տեսողությանը |
| Ճ | Ս | ✓ | Ակնոց կրելով կարելի է ուղղել աղոտ տեսողությունը |
| Ճ | Ս | ✓ | Շշիկները աչքի մաս են, որոնք օգնում են տեսնել գույները |
| Ճ | Ս | ✓ | Ակնաբույժին պարբերաբար այցելել անհրաժեշտ չէ, այլ միայն այն դեպում, երբ խնդիր եք նկատում |

+5

Վանդակներում նշե՛ք համապատասխան նիշը

1. Սպիտապատյան
2. Բիբ
3. Ծիածանաթաղանթ
4. Տեսողական նյարդ
5. Ցանցաթաղանթ
6. Եղջերաթաղանթ
7. Ապակենաման մարմին




+5

**Figure 19: Example Student Quizzes**

Overall, the survey showed positive feedback (Supplement 9). Most of the students said they had fun and all of the students said they learned something. The majority of them would return to the game in the future if given the chance (Figure 20). The students ages 6 to 11 thoroughly enjoyed the games, yet found some games difficult to play, which could also attribute to the decreased growth on the progress evaluation. On the other hand, older students understood the games and were able to play them without interruption or confusion. This enabled them to immediately practice and reinforce the knowledge from the videos, leading to a higher post-quiz score.

While the students played with the mock-up, we observed their behavior to determine if they were engaged. Behaviors such as smiling, laughing, or focusing on the screen were considered signs of enjoyment. Confusion or asking questions were considered signs that the games were too hard or did not make sense. We observed all of the students in each group and kept a tally of which students displayed the specified behaviors during each activity (Figure 21).

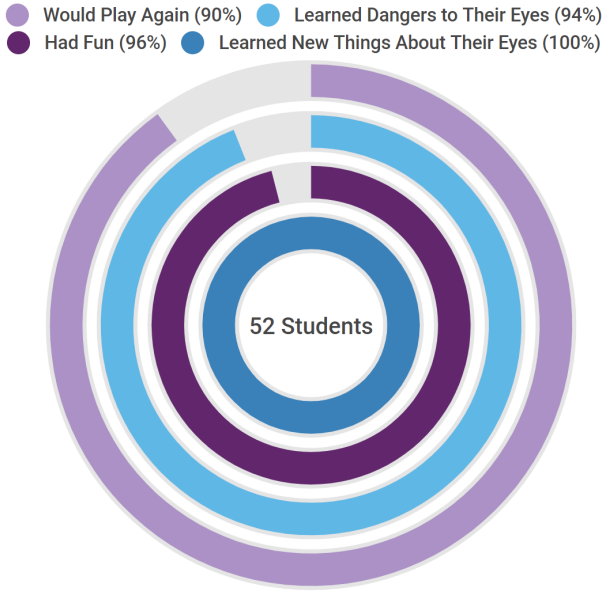



**Figure 20: Survey Summary**

The 6 to 8 age group required the most help, as they struggled with reading long directions and often needed to be shown how to play the games. The other two age groups were able to read directions on their own and learned how to play the game fairly quickly, with the exception of "Assemble the Eye." Many students did not realize that they had to scroll to find more parts of the eye, which initially caused confusion.

Along with their responses to the survey, our observations during play time also indicated they were enjoying the games (Supplement 10). Nearly 100% of students were focused on the screen during each of the activities. Almost all of the students replayed levels in "Protect the Eye" and "Colorblind Maze." These activities were the most competitive, so students would often replay to beat their high score. About 40% of students replayed the levels in "Search and Find." We believe that the low replayability of this game was due to students achieving perfect scores the first time they played. Students aged 9 to 14 finished finding the objects in the game quickly. As a result, they had no desire to replay the levels. However, students who did not have perfect scores, did replay and attempted to decrease their time. Not all students were smiling or laughing during the activities. We believe this was due to the nature of how children play games. They typically focus all their energy on the screen in front of them to avoid losing the game. However, they all showed smiles after they had finished. If there was extra time after playing all the games, we gave the students the option of playing any game they wanted. We found that 11 students returned to the "Colorblind Maze," 7 students returned to "Protect the Eye," 3 students returned to "Search and Find," and 3 students returned to "Assemble the Eye." We concluded that this was because "Colorblind Maze" and "Protect the Eye" have the best re-playability (Figure 21).

## Evaluation of Developers' Ability to Implement Our Design Document

In order for the AECP to move forward with their goal of creating a digital supplement for *Desunik's Game of Sight,* we created a comprehensive design document (Supplement 11). The document included all of the expected features, requirements and outcomes of the app. We brought this document to three development studios and evaluated them on cost, timeline, capability, and reputation using an evaluation scorecard (Supplement 12). Through our evaluations, we determined whether they would be capable of implementing the recommendations and dealing with constraints included in the design document.

The first developer we met with was X-Tech, an impressive medium sized company, with plenty of experience developing children's games in Unity. However, they heavily stressed their desire to convert the game entirely to

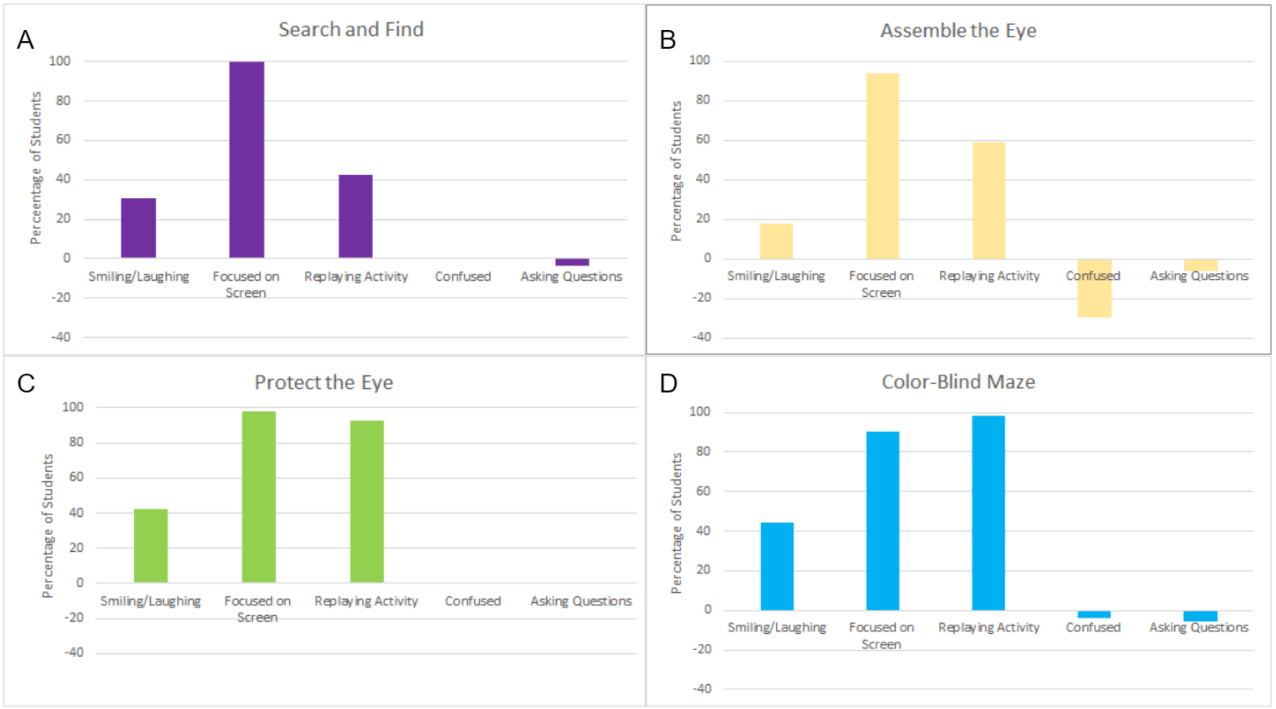



**Figure 21: Percentage of Students Displaying Each Body Language for Each Game. (A) Search and Find (B) Assemble the Eye (C) Protect the Eye (D) Color-Blind Maze**

augmented reality, which strayed too far from our recommendations and vision for the app. This made us feel uncomfortable allowing them to handle the development of the app.

The second developer evaluated was Vectual, a branch of a large French architectural digital imaging firm. It was clear they were knowledgeable from their fifty previous Unity applications, and their critical technical analysis of our recommendations. They claim they would be able to complete the app within 2-6 months depending on client feedback and budgetary constraints.

The final developer we met was a freelance contractor named Alex. His design expertise from his position as project manager at PicsArt is impressive. However, the lack of a concrete development team and game development experience left us wary of his ability to construct our final product.

In order to employ a development studio, the AECP will have to raise funds to cover the costs. We created a marketing package including a prospectus for the AECP to utilize when presenting to potential donors (Supplement 13).

The prospectus covered the following:

- Background on the AECP along with impressive statistics to establish their credibility
- Explanation of the need for a digital supplement of *Desunik's Game of Sight* and the impact that the app will have on Armenia and the rest of the world
- Our vision of the app design and structure.
- Current status of the app in the development life cycle (Figure 22).

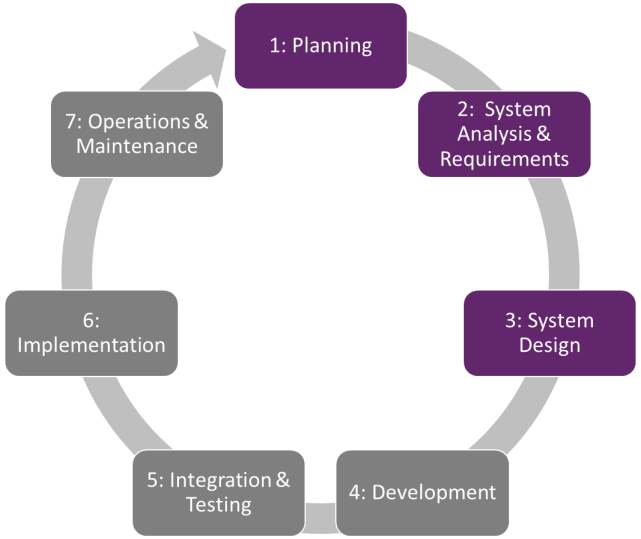



**Figure 22: Completed Steps of System Development Life Cycle**

## Conclusions and Discussions

Based on the results from our study, students enjoyed the digital *Desunik's Game of Sight* mock-up. The "Search and Find" activity was found to be the most enjoyable, but students lost interest after completing the three short levels. "Assemble the Eye" taught the students the most amount of material. In many cases, students got all of the parts of the eye wrong on the pre-quiz, but correctly identified them on the post-quiz as a result of playing the activity. From these findings, we believe these two games would make great contributions to the final version of the app. The remaining two games included in the mock-up ("Colorblind Maze" and "Protect the Eye") did not teach the students as much. Rather, these games were considered to be fun and entertaining to the students. This was expected, as they were intended to represent mini-games students could unlock. Some of the students had difficulty playing the games, while others found them to be too easy. In the final version, it would be best to have a wide range of difficulty levels.

Based on our findings, we conclude that a digital version of *Desunik's Game of Sight* has the potential to effectively educate students on eye care and eye health. We believe that the current structure of our mock-up — a short video followed by an educational game — will best transfer knowledge of eyecare and eye health. This structure presents detailed information in the video with games reinforcing that knowledge. One concern we have is if the games focus too much on education, the students will not find them as enjoyable as other apps available to them. However, if the games do not focus on education enough, the students will not learn anything. This is why we believe that the combination of video lessons followed by games will work best with students.

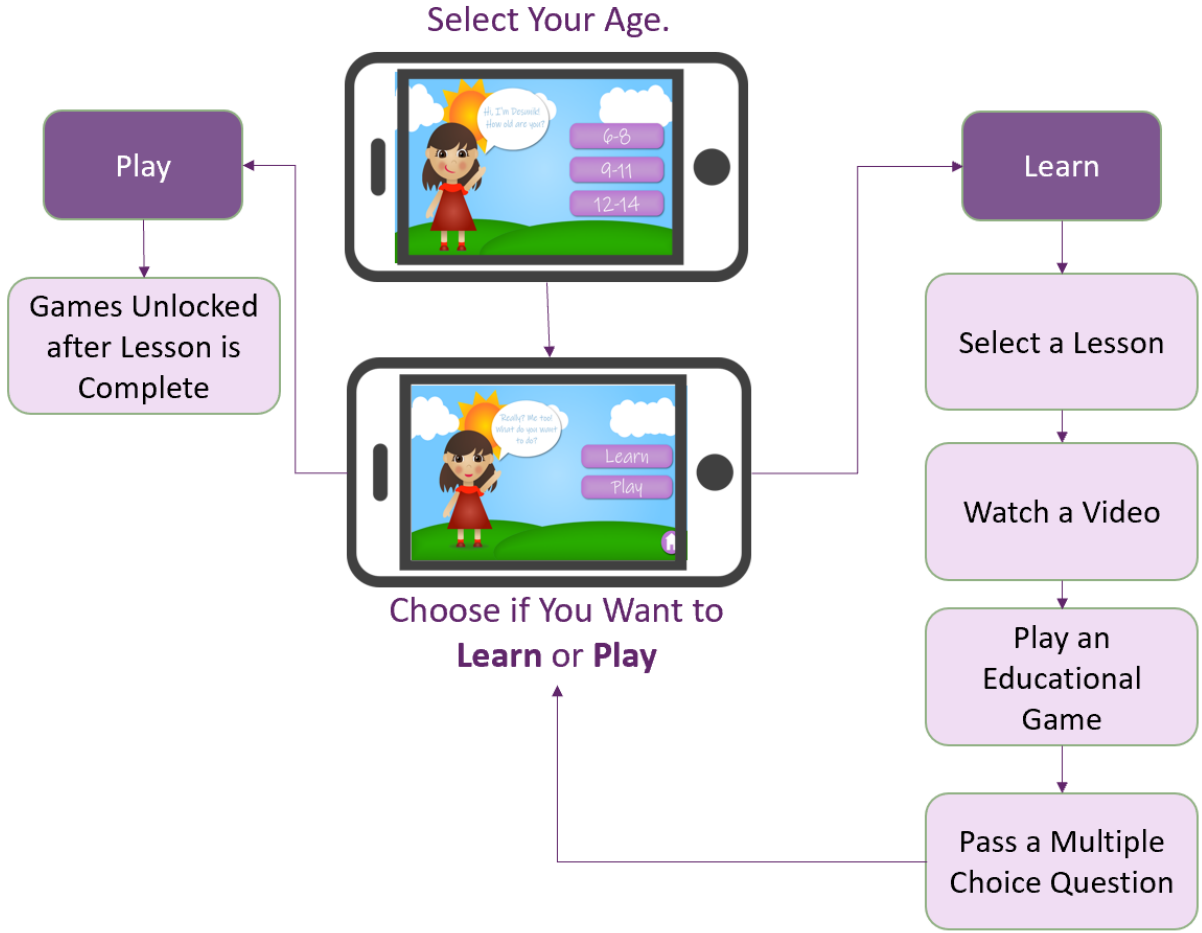



**Figure 23: Application Structure**

Of the three developers we reviewed, we concluded that Vectual is most qualified to implement the app for the AECP Vectual has the tools, business organization, professionalism, and experience to complete this project within our specifications. Additionally, we believed the connection of Dr. Jrbashyan and her daughter, Arpy Vanyan, a developer at Vectual, will increase clarity and effectiveness in communication between the AECP and development team.

# Provided Recommendations and Implementation Plan for AECP

Since the structure of the mock-up effectively taught the content in an enjoyable way, we recommend that the AECP uses a similar structure for the final version of the app (Figure 23). The videos should be more detailed than those created for the mock-up but only cover one lesson each. We recommend dividing the knowledge into 12 separate lessons:

- What is vision / sight?
- What are your eyes?
- What are the parts of your eyes?
- How do your eyes work?
    - Light inversion
    - Colors / color blindness
    - Depth perception / convergence
- What are dangers to your vision?
- How to keep eyes healthy for good vision?
- What are refractive errors?
- Why wear glasses?
- What do eye doctors do?
- What are eye diseases?
- How to protect your eyes from injuries / what to do if you injure your eye?
- How do blind people read?
- Brail / white cane

We also recommend that the AECP focuses on the development of two or three games, rather than all eleven of the games we evaluated. This will increase the quality of implemented games. If the initial version of the app is proven to be successful, a case can be made for more funding to add additional games. At this time, the games that we recommend are "Search and Find," "Assemble the Eye," and "Eyelash Dash," the latter of which was not included in the mock-up. "Eyelash Dash" scored extremely high for both our enjoyability and educational criteria and is similar to *Subway Surfers,* which is the third most frequently downloaded game in Armenia. "Search and Find" and "Assemble the Eye" both showed success during testing of our mock-up. However, we recommend that "Assemble the Eye" be more visually interesting than the way it was presented in our mock-up and "Search and Find" should include more levels. From our testing, we believe our recommendations will create an app that effectively teaches eyecare to students.

As part of our recommendation document (Supplement 14), we included a timeline for the final implementation of our plans (Figure 24). This plan spans one year and includes 2 months of contingency for both development and securing funds to account for unexpected delays. To begin, the AECP should select their developer and finalize the plans for the application. While we concluded that Vectual is the best of the three developers we reviewed, the AECP may want to look at additional companies using our design document and developer scorecard. Making the plan as concrete as possible in the beginning will allow for developers to be more efficient and effective in meeting the goals of the AECP. During this time, the AECP will need to raise funds for the application. This could take a week or multiple months, so we have accounted for a three month fundraising period as this process may take some time. An app is a unique and novel idea for the AECP so donors may be hesitant at first. Most developers we met with estimated a four month development period. During this time, weekly or biweekly iterations will be reviewed by the AECP to ensure good progress is being made. When a prototype is good enough to be tested, the AECP should test the app with students to ensure that it still meets the educational and enjoyability standards. Finally, the app will need to be added to the app store, distributed to schools, and

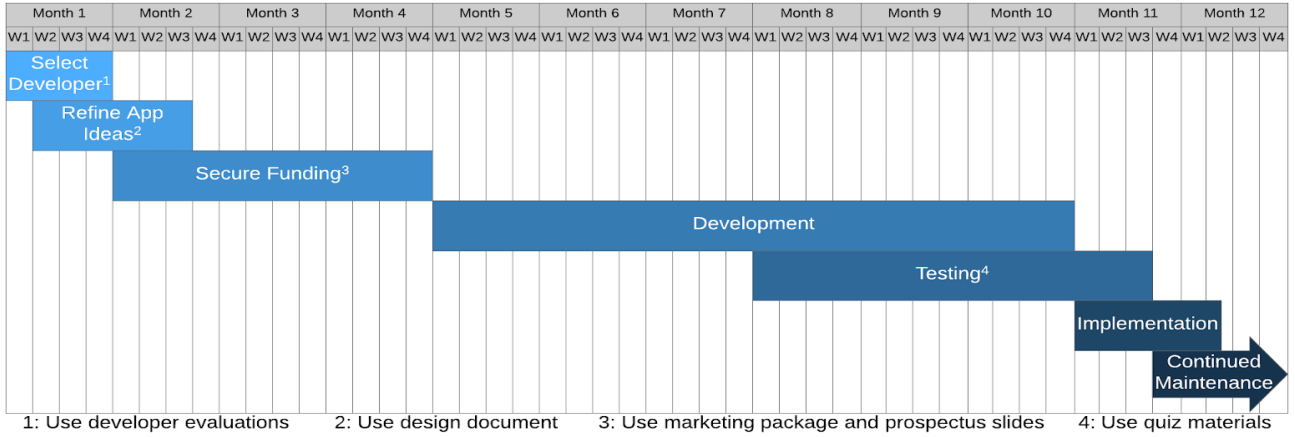



**Figure 24: Implementation Plan Timeline**

continually maintained for the future. Our recommendations include potential future additions and depending on the success of the app, the AECP may want to add updates to improve it. Continued updates will keep the app fresh and re-playable to ensure continued education through the entire age range desired by the AECP.

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# Armenia, 2019

Thank you for a wonderful time!