# ΛMANDΛ

EMBRACE-THE-DIFFERENT

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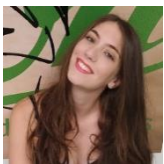
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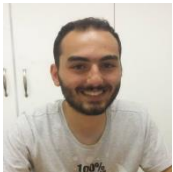
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AMANDA LINKS: www.amandaproject.net; www.facebook.com/amandamuseum; www.twitter.com/amanda_project

The problem

Childhood is an extremely sensitive period in human development, during which the brain, especially the circuitry governing emotion, attention, self-control and stress, is shaped by the interplay of the child's genes and experiences[1]. One of the unfortunate experiences that marks many childhoods is bullying[2]. Bullying is a global social phenomenon that has existed in neighborhoods and schools for centuries and is still rising in the twenty-first century. It is defined as **aggressive** behavior that is **persistent**, **intentional**, and involves an **imbalance of power** or strength[3]. It usually targets children and teenagers due to their lack of empathy, which is the capacity to understand or feel what another being is experiencing from within the other being's frame of reference, i.e., the capacity to place oneself in another's position[4]. There are four types of bullying, that is, *verbal*, *physical*, *relational abuse* and *cyberbullying*. According to the U.S. Department of Health and Human Services, **one in three U.S. students** say they have been bullied at school. At the same time, 30% of young people admit to bullying others, while 70.6% of young people say they have witnessed bullying in their schools. The cost of that is 4400 bullycides/year[5].

The main roles identified in bullying include the **bully**, the **victim** and the **bystander[6]**, with a negative impact on everyone involved. In particular, for the bullies, the consequences vary from violent behavior and antisocial personality disorder to educational problems, while the victims face anxiety, depression symptoms, lower self-confidence and even suicidal tendencies. Finally, the bystanders tend to feel fearful and powerless to act and guilty for not acting. **A major problem in bullying is the distinction of these roles**, since a student can have multiple roles: s/he can be the one subjected to bullying and the one who bullies, depending on his/her social surroundings, imposing difficulties in the realization of effective interventions.

Solutions so far involve questionnaires and conversation with experts and psychologists for detection of bullying. Without proper stimuli before the questionnaires, though, answers are obscure. Furthermore, children tend to hide information from parents and experts when it comes to bullying incidents (64% of children who were bullied did not report it[7]). For intervention, mainly lectures from various organizations are provided, trying to increase bullying awareness. These solutions, however, are not personalized for each young, are not dynamic and cannot retain a child's interest. Therefore, they cannot offer a holistic solution to the problem.

AMANDA – The vision

Motivated by the aforementioned, AMANDA[8] proposes an intelligent ICT-based approach for bullying detection and intervention in children's everyday life, by introducing new ways of behavior self-managing tools, set within a collaborative care context with psychology professionals. Specifically, the main aim of AMANDA is **to create an ICT-based, gamified behavioral analysis approach for capturing bullying tendencies and to apply ICT-based interventions countering identified risks based on bullying detection, relating to low empathy, self-confidence and awareness.**

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[1] http://cahs-acss.ca/wp-content/uploads/2015/07/ECD_Executive-Summary.pdf
[2] http://www.bullyingstatistics.org/content/child-bullying.html
[3] http://www.ncpc.org/resources/files/pdf/bullying/21st%20Century%20Bullying%20-%20Crueler%20Than%20Ever.pdf
[4] The English word empathy is derived from the Ancient Greek word ἐμπάθεια (empatheia, meaning "physical affection or passion"). This, in turn, comes from ἐν (en, "in, at") and πάθος (pathos, "passion" or "suffering").
[5] http://www.bullyingstatistics.org/content/bullying-and-suicide.html
[6] http://www.education.vic.gov.au/about/programs/bullystoppers/Pages/impact.aspx
[7] http://ies.ed.gov/ncee/edlabs/regions/northeast/pdf/REL_2010092_sum.pdf
[8] The name AMANDA was selected as a tribute to Amanda Todd, a 15 yrs old girl that committed suicide due to bullying she experienced.

AMANDA – Architecture

The general architecture of AMANDA is depicted in Fig. 1. From the latter, the two main modules of AMANDA, i.e., bullying detection and intervention, drawing data from the AMANDA community, are evident. These are described in details in the succeeding sections.

AMANDA Community

The structure of AMANDA involves a pool of participants aged 5-15 yrs that form the AMANDA Community. The number of members of this community is expected to continuously grow across the use of AMANDA, taking into account the prevalence of bullying in the adolescence population and the awareness initiatives of AMANDA via the social media and the already established collaborations with relevant communities, e.g., the European Antibullying Network (EAN, http://www.antibullying.eu/), The smile of the child (http://www.hamogelo.gr/), Arsakeia Schools (www.arsakeio.gr), Lexicon Schools (http://www.lexicon-edu.gr/). To further support the expansion of the AMANDA community size, AMANDA will target psychologists' and experts' clients, as they have already turned towards specialized help.
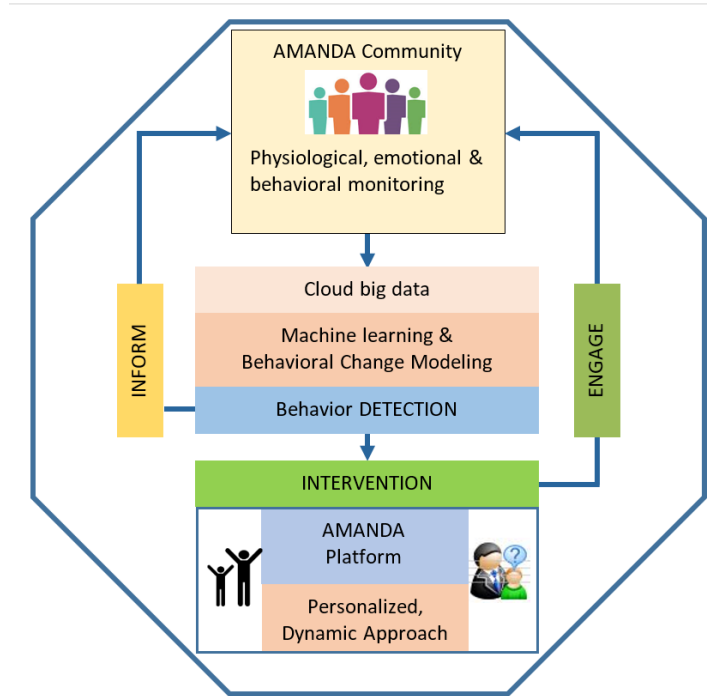

Fig. 1. AMANDA's general architecture framework.

AMANDA Detection Module

The underlying common factor in the three roles identified in bullying, i.e., bully, victim and bystander, is the behavior. Changes in the latter, due to the difference in the corresponding role, are reflected in the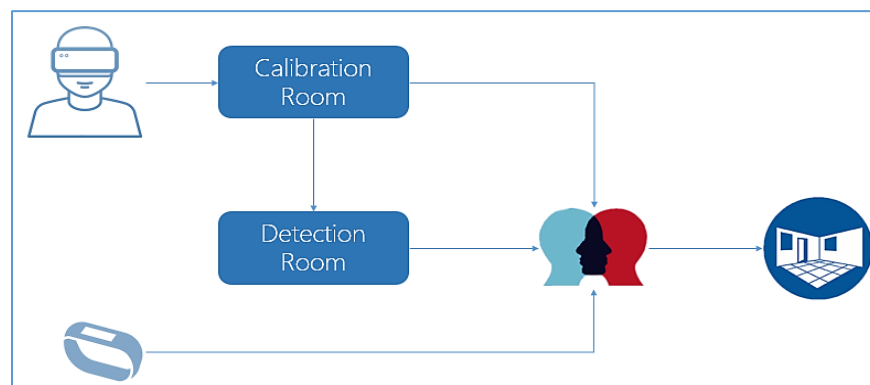 three basic characteristics of *empathy*, *self-confidence* and *awareness*, accordingly. Unlike the static approaches adopted so far, AMANDA captures these characteristics by combining young's behavioral information dynamically acquired both from the **Real World (RW)**, the **Virtual Reality (VR)** and the **Augmented Reality (AR)** worlds, shaped by a gamified structure. This innovative approach supports AMANDA's holistic nature and fosters the capturing of young's true experience related to bullying stimuli. Pragmatically, the VR and AR words are realized via the use of a smartphone attached on a VR headset (e.g.,
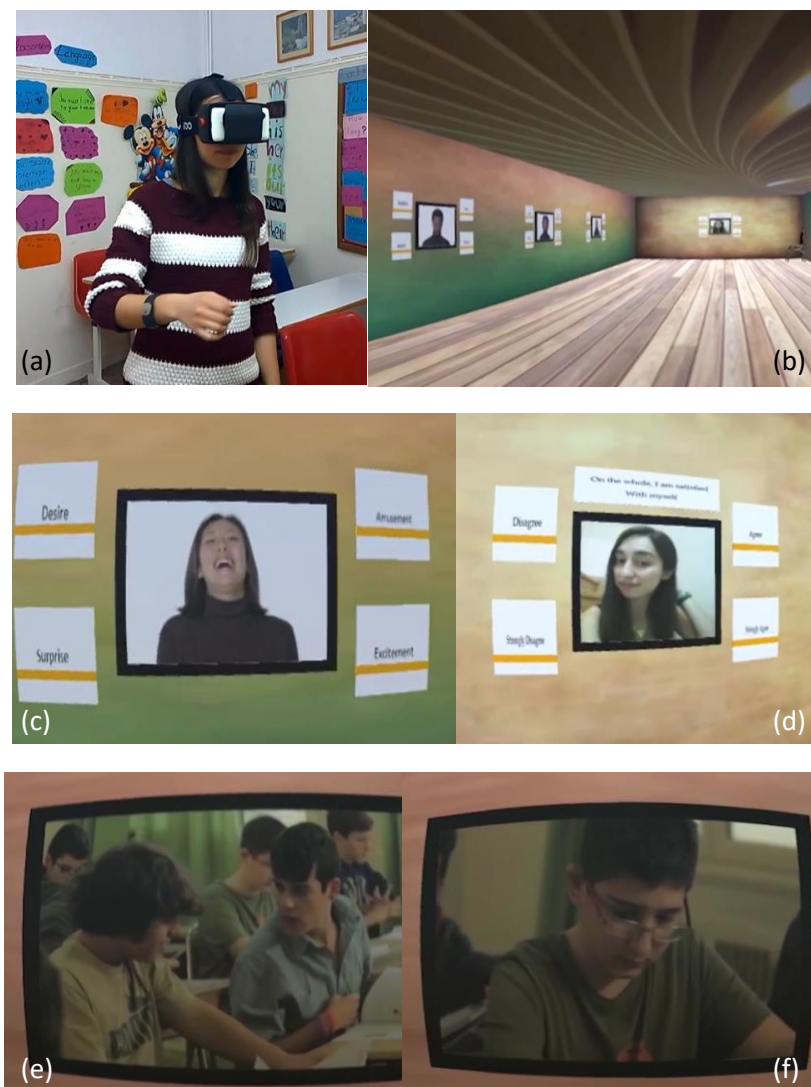

Fig. 2. Architecture of AMANDA Detection Module.

Fig. 3. (a) AMANDA's merging of the RW and VR/AR environments via the wearing of the MS Band (RW) and the HOMIDO headset with an attached smartphone (VR/AR), (b) AMANDA's Calibration Room, (c) Facial emotional stimulus with four possible emotion selections, (d) Selfie stimulus for self-confidence calibration, (e) & (f) Emotional stimuli related to bullying during the three level game-route in the Detection Room.

HOMIDO, Google Cardboard), as shown in Fig. 3(a). In the AMANDA Detection Module (see Fig. 2), the young is welcomed by Cortana into a VR world (see Fig. 2-Callibration Room, Fig. 3(b)), where s/he interacts with facial stimuli of Ekman's six basic emotions[9] (e.g., faces expressing anger, disgust, fear, joy, sadness, surprise), and the game-task s/he undertakes is to correctly identify the displayed emotion (Fig. 3(c)). The idea behind is to categorize the initial level of the young's emotional intelligence (calibration phase), taking into account the activation of his/her brain mirror neurons expressed via his/her empathy[10]. Note that the last (seventh) image is a selfie of him/herself and s/he has to select the level of his/her self-confidence (see Fig. 3(d)). The young's choice is realized by staring at the one from the four available answers for five seconds. The young's emotional and self-confidence choices, the time spent for his/her respond and his/her routing within the VR world are continuously captured by AMANDA Detection Module. Apart from this information in the VR world, his/her biometric signals from the RW (i.e., heart rate, skin temperature, galvanic skin resistance) are registered with the use of the MS Band. In order to create a sense of a coexistence of both RW and VR environment, the MS Band accelerometer is used as course navigator, since the young cruises within AMANDA VR world by accordingly twisting his/her wrist (anti/clockwise for backwards/forwards). After the end of the calibration phase, the young enters a consequent room (see Fig. 2-Detection Room) of emotionally targeted content, specifically related to bullying, categorized into

three levels that include certified videos that expose the three different roles of bully, victim, and bystander, evoking related emotional stimuli, respectively (see Figs. 3(e), (f)). The young here has to pass through the three levels as a game-route and at the end s/he is asked which one of the three roles express her/himself. During this route, the AMANDA Detection Module monitors the time spent and way of routing within each level of the VR world, to identify the young's attention and the level importance, according to his/her level selection. In addition, the biometric signals are continuously captured. Taking into account the information from the calibration phase and the one from the Detection Room, the AMANDA Detection Module constructs a personalized behavioral vector of the child (see succeeding section), that is used to dynamically adjust the VR space that follows in AMANDA to the young's identified behavior (see Fig. 2). In

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[9] https://www.paulekman.com/wp-content/uploads/2013/07/Basic-Emotions.pdf
[10] Iacoboni, M. (2009). Imitation, empathy, and mirror neurons. *Annual review of psychology*, 60, 653-670.

this way, the particularities of the reaction of each young (in both RW and VR) are becoming structural factors for the his/her gamified environment that follows.

Behavioral model

The architecture of the AMANDA Behavioral Model is depicted in Fig. 4. From the latter, the following structural characteristics could be identified.

Big Data Sources: Big data involved in AMANDA refer to specific sources, i.e., biometrics and behavioral data. These data are stored in the Azure Cloud and are subjected to the following feature extraction analyses:

1. Biometrics Features: The recognition of facial expressions and the ability to infer the likely mental states of other people are an important feature of social cognition and this ability may predict functional social

Fig. 4. Architecture of AMANDA Behavioral Modeling.

capacity beyond more traditional neurocognitive assessments that index working memory, psychomotor speed, and attention. According to research[11], there exists a positive association between emotion recognition (empathy) and one's

biometrics, as those extracted as raw data from the MS Band. Similarly, self-confidence can be related to biometrics[12]. In both cases, noise removal filters are applied to the biometrics data and the denoised signals are zero-meaned. The biometrics are then analyzed in time and frequency domains and features, such as High Frequency Fourier Transform (HF_FT) (see Fig. 5) and Difference of Standard Deviations (D_SDT), are extracted for each signal. Then, the Kendall Correlation Feature Selection Algorithm is used[13] and only the most important features are kept while the rest are discarded.

Fig. 5. Power spectral density of biometric data with identified frequency bands used as biometrics features.

2. Behavioral Features: The accelerometer and gyroscope data from the smartphone combined with the young's position inside AMANDA's space, reflect his/her routing inside AMANDA. This information is combined with the young's responses (choices, timings, attention, importance), forming behavioral features regarding his/her reaction to specific stimuli.

Behavioral Modeling: AMANDA aims at creating a model of bullying-related behavior changes, quantified in real life across a population sample. This model is used to extract dynamic evaluations for the current state of an individual concerning empathy and self-confidence. The model is fed by the aforementioned biometrics and behavioral features and it is realized as an Azure Learning Machine (see Fig. 4). The behavioral model is continuously built and trained to
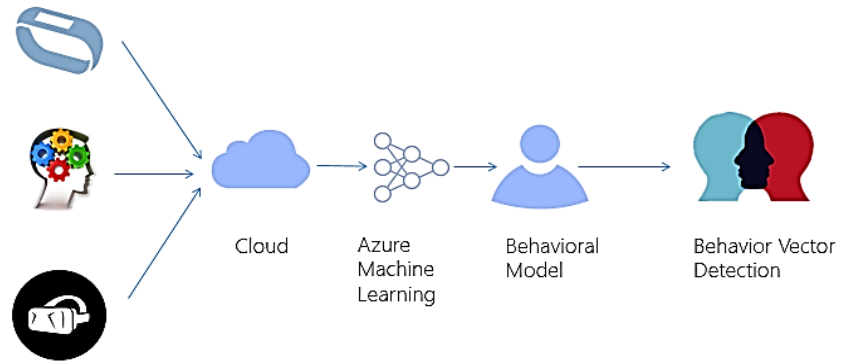
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[11] Quintana, D. S., Guastella, A. J., Outhred, T., Hickie, I. B., & Kemp, A. H. (2012). Heart rate variability is associated with emotion recognition: Direct evidence for a relationship between the autonomic nervous system and social cognition. International Journal of Psychophysiology, 86(2), 168-172.

[12] O'Donnell, K., Brydon, L., Wright, C. E., & Steptoe, A. (2008). Self-esteem levels and cardiovascular and inflammatory responses to acute stress. Brain, Behavior, and Immunity, 22(8), 1241-1247. doi:10.1016/j.bbi.2008.06.012

[13] Hulse, J. V., Khoshgoftaar, T. M., Napolitano, A., & Wald, R. (2012). Threshold-based feature selection techniques for high-dimensional bioinformatics data. Network Modeling Analysis in Health Informatics and Bioinformatics, 1(1-2), 47-61. doi:10.1007/s13721-012-0006-6

assess the behavioral changes of each user related to bullying symptoms. This assessment is expressed as empathy and self-confidence scores and a Decision Forest classification mechanism[14] is used in the sequel to produce probabilities and/or severity indices.

AMANDA Intervention Module

AMANDA proposes a series of innovative ICT-based interventions, both at VR and AR worlds, applied to every child in order to achieve a holistic solution to bullying. The architecture of AMANDA Intervention Module is depicted in Fig. 6.

Intervention @VR world: As it was already mentioned, the output of the behavioral model affects the structural characteristics of the VR world used in the intervention module. Actually, AMANDA dynamically adjusts to the special characteristics of the young the VR space, which changes and becomes personalized according to the behavioral vector of the child,
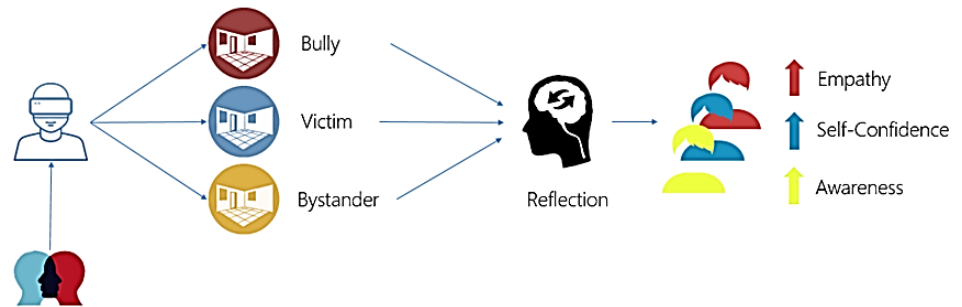

Fig. 6. Architecture of AMANDA Intervention Module.

following the three categories of bully, victim and bystander of Fig. 6. The content in these VR spaces is formed with the appropriate audiovisual material that, according to neuroscience, can positively affect the young's behavior. In fact, the young's emotional engagement is used as a game-parameter that controls the navigation in that space. When the young inside the corresponding VR space sees a video with specific content (e.g., anti-bullying), s/he has to be emotionally engaged with it, in order to be able to proceed to the next vista (see Fig. 7). This is controlled by the aforementioned trained behavioral model that dynamically outputs the level of empathy and self-confidence (see bars in Fig. 7). At the

Fig. 7. Change in the empathy level (see yellow bar) allows the young to shift form an inactive and dark intervention room (left) to a spot-lighted and active one (right). The red bar denotes the level of young's self-confidence.

same time, gamification features, such as the completion of tasks, collecting points and the completion of achievements, render the application not only useful and effective, but also entertaining, further engaging the user. These interventions (currently under development) aim at the enhancement of empathy, awareness and self-confidence of the user (see Fig. 6).

Intervention @AR world: After the finalization of the young's interaction with the VR world, the world of AR is employed. Now, in his/her RW, a memory from the VR world (e.g., a video) is superimposed to the RW via AR (see Fig. 8); the reflected information aims at the optimal consolidation of the his/her experiences in the VR world, guiding the young in

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[14] Loh, W. (2011). Classification and regression trees. WIREs Data Mining Knowl Discov Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery, 1(1), 14-23. doi:10.1002/widm.8

a reflection process. More specifically, the moments in his/her VR course when s/he demonstrated the highest emotional engagement according to behavioral model output are reinforced via the AR (see Fig. 8). In that way, AMANDA fosters the transmission of emotions and experiences from the virtual to the real world, allowing AMANDA to not just be a simple gaming experience, but to positively affect the young in his/her everyday life.

AMANDA+ Psychologist's (Expert's) view

AMANDA gathers quantitative, dynamic interaction information and provides with behavioral model outputs; these make AMANDA a resourceful tool for the psychologists/experts in the field of bullying. To this end, AMANDA provides a psychologist's app, where s/he can

Fig. 8. An emotionally charged memory from the VR world (video in black square) is superimposed on the RW of the young (on her announcement board) via AR.

monitor his/her use-cases (children/youngers) and be able to replay any previous session of a child (see Fig. 9). In this vein, the expert can observe any behavioral characteristic that considers important combined with the information from AMANDA's behavioral model

Fig. 9. The psychologist's app, where the expert could organize his/her use-cases and re-examine all the behavioral interactions of the child with AMANDA RW/VR spaces, combining its behavioral modeling output.
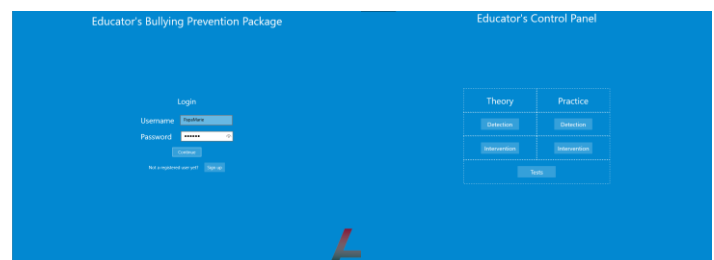
output during play time, forming, thus, a much more pragmatic perspective of the true feelings of the child and properly inform his/her family and school environments.

AMANDA+ Educator's (Expert's) view

AMANDA considers that a holistic solution to the problem is needed and therefore proposes an additional platform where the educators (Fig. 10) could improve their knowledge and skills when it comes to bullying detection and intervention in school environments. Through this, the educator can practice on many and diverse use case scenarios. Upon completion of these s/he will be eligible for a certification test, serving as proof of his/her expertise on these matters.

Fig. 10. The educator's app, where the educator could acquire the knowledge to detect and intervene in bullying incidents, practice various use-cases and participate in certified examinations as proof of their expertise.

Use case scenario – A future school experience

Laura and Tomas are two junior high school students, 13 and 14 years old, respectively. Tomas is having trouble with other boys and especially Mike and his friends, who are tormenting him. Laura is present during these incidents but she is afraid to react. Just recently, their school became a member of AMANDA Community, participating in the innovative anti-bullying AMANDA program. For this reason, their teacher, Jessica, suggested them to download the free AMANDA application and take a tour in its VR/AR world with the help of the MS Band, combined with their smartphone (android/windows phone) and a simple cardboard, supplied by the school as well, once the AMANDA Educator's package was bought. Laura, Tomas and Mike were impressed by AMANDA, as it was the first time they saw the combination of the MS Band with VR/AR and they found the application pretty cool, simple and fun to use, since the gamification features

engaged their attention. They even started talking to each other about their experience inside the AMANDA space and their effort to reach emotional coupling with its content, in order to unlock more levels. This motivated Jessica to include AMANDA in her teaching schedule and download updated material from the AMANDA's marketplace, extending the students' awareness about bullying. Jessica, with the help of AMANDA's Educator package, can now easily recognize bullying scenes, along with her students' behaviors and how to reach them. Thus, she understands Mike's failure to grasp Tomas' feelings, since he is still harassing him. Therefore, she approaches Mike and suggests that he makes an appointment with the school psychologist, Jack. Mike visits the psychologist, who utilizes AMANDA's Psychologist's package as an invaluable tool against bullying. Hence, Mike reenters AMANDA's virtual/augmented world, while in this case Jack can monitor Mike's biometrics and his behavioral characteristics. At the same time, Jack has access to the behavioral model's results in real-time. Afterwards, he can watch Mike's session, with the "replay session" feature, and reach a clear conclusion on his needs and behavior. Consequently, Jack knows exactly where he needs to focus in order to provide a holistic and final solution to the problem, informing both Jessica and Mike's parents.

There have been three months since the use of AMANDA at high school and Jessica has observed a substantial reduction in bullying incidents, as well as different behavior from particular children in the classroom. Students, now, exchange thoughts and feelings they experience and truly understand how the others feel. Jessica can see that students who bullied others in the past, by using AMANDA have increased their level of empathy, while students who were victimized now have greater self-confidence. Besides, everybody is now aware about the consequences of their action to others. Actually, Tomas, starts his own conversations full of confidence, while Laura no longer stands uninvolved in similar bullying situations. Moreover, Mike has totally altered his behavior and became a teammate with Tomas and Laura in the robotics laboratory project, working altogether; they even share the same dream: someday to invent the emotional robot; they have already decided to name it …AMANDA!

Technologies Used

-Development Tools: Unity 5, Visual Studio 2015 Enterprise, Android Studio, Blender**-Cloud computing**: Microsoft Azure Platform (Machine Learning, Wordpress, Blob Storage)**-Other Technologies**: C#, Java, WPF, Matlab, Android, Windows 10, Vuforia SDK, ALPS SDK, Google Cardboard SDK, Adobe Premier, Windows Movie Maker, Syncfusion Metro Studio**-Hardware**: MS Band, Windows phone, Android Phone, Windows PC, Windows tablets, Google Cardboard, HOMIDO**-Interfaces Developed:** *AMANDA Mobile*: The Windows & Android phone is placed in the VR headset and connected with the Microsoft Band. The user can move forward or backward with MS Band's gyroscope and turn right or left with smartphone's gyroscope. *AMANDA Psychologist's App:* Windows 10 (PC/Tablet) application that enables the psychologists to monitor their patients and replay previous sessions. *AMANDA AR*: Android App that integrates digital information with the user's environment in real time (Augmented Reality)**-Microsoft Azure Servers and Machine Learning:** The core of AMANDA project. All data collected are being sent to our servers where they are categorized and passed through signal processing and machine learning algorithms with Azure Machine Learning.

Privacy Awareness-Ethical Issues

The bloom of big data is accompanied by the quest for privacy aware learning. Privacy is important since training data are of highly sensitive kind. In AMANDA, all data (biometrics and behavioral) are sent encrypted to Microsoft Azure Servers that follow all the privacy standards. In particular, Windows Azure cloud platform allows customers to meet Health Insurance Portability and Accountability Act (HIPAA) regulations on business associate agreements. Azure allows customers to encrypt data and manage keys, and safeguards customer data for applications, platform, system and storage using encryption, segregation, and destruction[15]. Moreover, AMANDA considers all the ethical issues involved in

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[15] http://azure.microsoft.com/trustcenter

the users' interaction, asking from them their consent about allowing data capturing and optionally providing personal information (such as age, gender, name). A unique identification number is generated for each user after s/he provides consent and it is used on all information sheets and data collected instead of the name of the user.

From a Cost-Effective Business Perspective

Impact on Behavioral Health and Market Approach: The increasing demand for effective and quantitative results in psychology will drive the combined use of the state-of-the-art technology and medical research necessary to model and understand the person's behavior and sentiment, and, consequently, result in favorable investment opportunities. For the case of bullying, AMANDA provides a new holistic approach that has never been attempted before, in order to combat bullying in an innovative and effective way.

AMANDA Target Group: AMANDA will reach via dissemination activities: (i) **End-user:** children, educators, schools and psychologists, (ii**) Clustering Initiatives**: the establishment of formal liaisons between the project and the various initiatives will be pursued, i.e., the European Antibullying Network (EAN); Pacer's National Bullying Prevention Center; Amanda Todd Legacy, (iii) **VR/AR Companies**, providing virtual reality experiences, apps and games that would like to expand their market segment towards incorporating apps with a more sophisticated character, and (iv) **Wearable technology companies**, that would like to extend the need and use of wearable technologies in medical and psychological applications.

Market Analysis: The global Virtual Reality Head-Mounted Display shipments are expected to reach the number of 25 million by 2020, at a CAGR of 99% between 2015-2020 according to BI's forecast. The major reason for the growth is the increasing use of smartphones, adoption of advanced technologies, implementation of software application in mobile computing and the fact that virtual and augmented reality software applications are easy to be developed for smartphones. As far as the wearable device units are concerned, the global shipments are expected to reach the number of 150 million by 2019, at a CAGR of 35 % between 2014-2019 according to BI's forecast. Wearable technology, fueled by a frenzy of hype, funding and global interest, has catapulted to the top of the agenda for companies spanning the entire value chain and world.

Market Dynamics: Evaluating the dynamics of our target market, we will also consider the new opportunities that will arise from extending our collaboration with VR and Wearable technology companies that are interested in combining their products with behavioral change data and models; these would be approached via the AMANDA partners related with psychology and researchers in Signal Processing and Biomedical Technology Unit (SPBTU) of AUTH and we are already in touch with schools, where we can develop our services. We should mention that the modules that are being developed in AMANDA can also potentially become part of mainstream
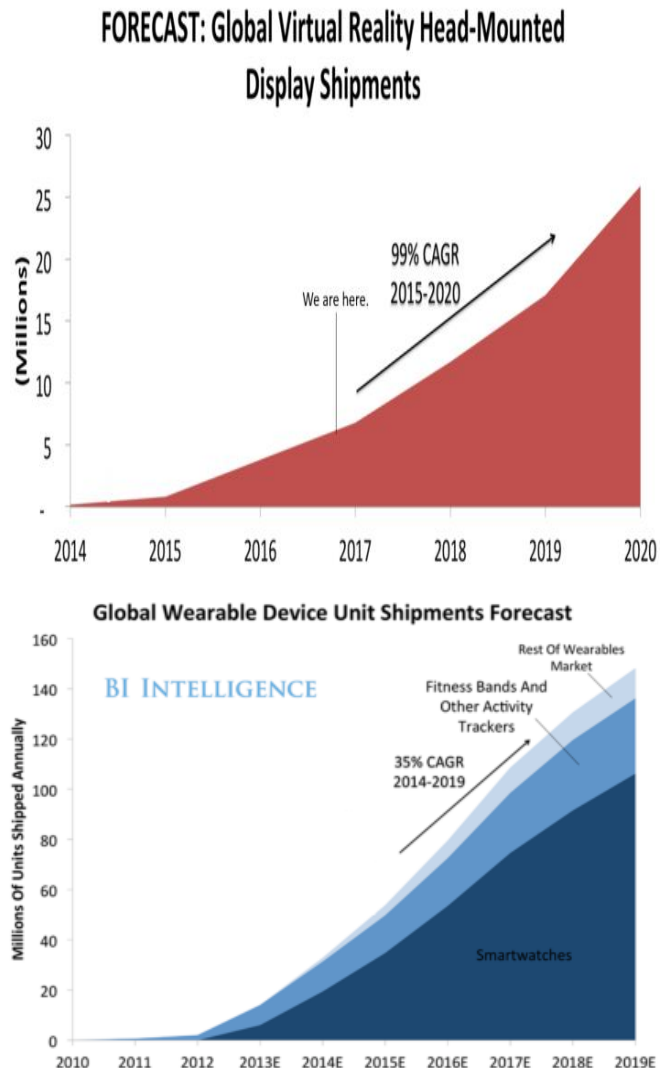

Fig. 11. (Top) The Global Virtual Reality Head-Mounted Display Shipments and (Bottom) the Global Wearable Device Unit Shipments Forecast according to the Business Insider Intelligence.
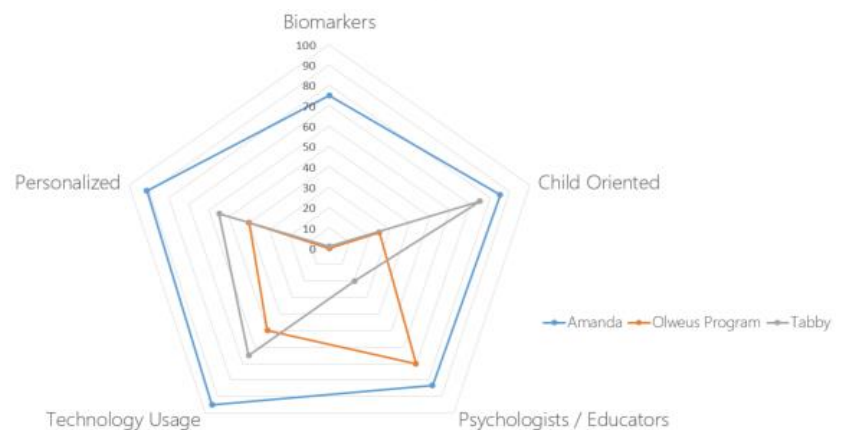
interventions, not only for bullying but for broader end-users, as our solution can target related issues of low empathy and self-confidence, which could be met in many other situations like the **refugee's crisis**.

SWOT Analysis: The resulted SWOT analysis of AMANDA is illustrated in Fig. 12(a). It is important for AMANDA that is sponsored by the "Microsoft Patent Program" in order to file a U.S. Patent for the whole idea, a fact that has eliminated a previous threat that was AMANDA to be copied by a big technology company.

Competition: The competition analysis of AMANDA is illustrated in Fig. 12(b). AMANDA outmatches each one of the competitors on fundamental features. These are the use of the benefits that Technology and Biomarkers in order to provide effective and quantitative results on combatting bullying. Also, the fact that AMANDA has Personalized and Child-Oriented perspective but applies to Psychologists and Educators too creates a powerful tool for addressing the problem effectively and holistically.

Monetization Approach and Marketing Strategy: We plan to adopt a monetization approach based on the Software-as-a-Service (SaaS) model. The four different products are depicted in Fig. 12(c). The AMANDA mobile App modules will be freely downloadable from the Marketplace, while the AMANDA psychologist's App will be offered to psychologists in a low fee (e.g., US$9.99 per month) and a registration cost (e.g., US$499 including equipment), while educators App will be offered to educators and schools with a registration fee (e.g., US$499) and an optional certification procedure (e.g., US$99) that will certify the knowledge of the educator concerning bullying. Equipment is not obligatory to be purchased from us, so the Psychologist's and Educator's Package will be offered and in a Standalone version where installation and specification guides are going to be given. The cost of the two different Standalone versions

	Registration	Subscription	Certificate	Revenue Percentage
Mobile App	Free	Free	-	-
Psychologist's Package	499 $ Full 99$ Standalone	9.99 $	-	-
Educator's Package	499 $ Full 49$ Standalone	-	99 $	-
Market Place	-	-	-	15%

Fig. 12. (a) The Strengths, Weaknesses, Opportunities and Threats of AMANDA. (b) The analysis of the competition. (c) AMANDA's Framework (d) AMANDA's Monetization Table

are depicted in the Fig.12(d). Furthermore, developers will be given the opportunity to develop their own rooms which could be embedded to the existing app (through the Market Place), provided they fit our criteria. A revenue of 15 % will

be provided to us for monitoring, ensuring and securing the whole process. Moreover, a flexible approach of Business to Consumer (B2C) (focus on the benefits of the product) and Business to Business (B2B) (focus on the logic of the product) will be exploited. This is important for the exploitation of the behavioral big database and models to be produced during
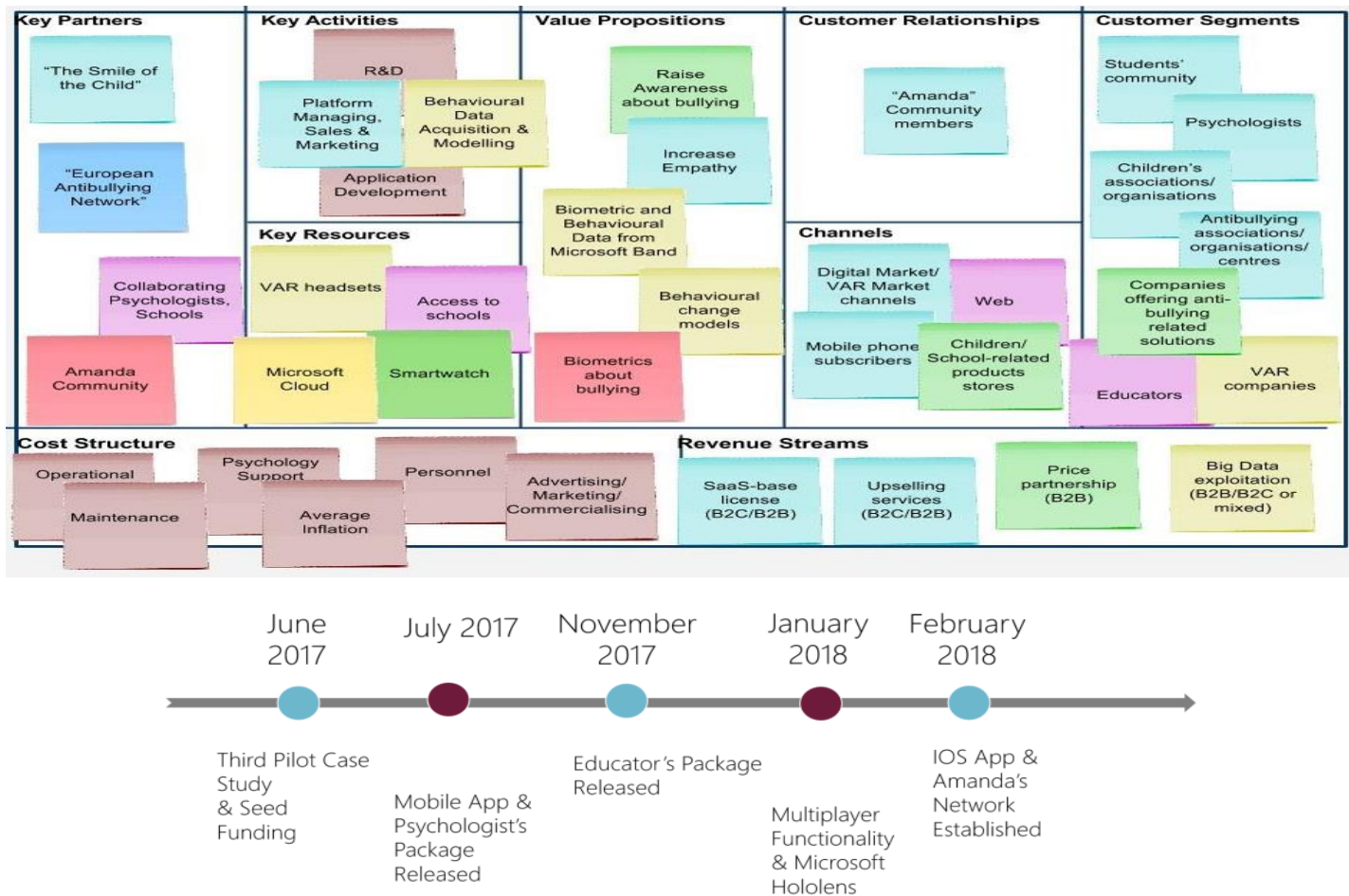

Fig. 13. The canvas analysis of AMANDA (top) and the anticipated milestones across timeline (bottom).

the realization of the AMANDA, especially when contacting public schools massively. Start-up requirements in finances are provided by AUTH, which acts as our angel investor and the Microsoft Corporation which has provided AMANDA with financial, equipment and legal support. A provisional business plan (canvas) of AMANDA is depicted in Fig. 13 (top), whereas the anticipated milestones across timeline are illustrated in Fig. 13 (bottom).

Break-Even Scenarios: The Optimistic, Medium and Pessimistic break-even scenarios are illustrated in Fig. 14. In the optimistic scenario, AMANDA is going to reach the break-even point of the 220.000 $ by September 2017. In the moderate scenario, the break-even point is going to be reached only after the Educator's Package release. The declining values that are depicted in the month of November illustrate the need of invest for marketing, advertising and public relations in order to spread the Educator's Package in as many schools as possible. In
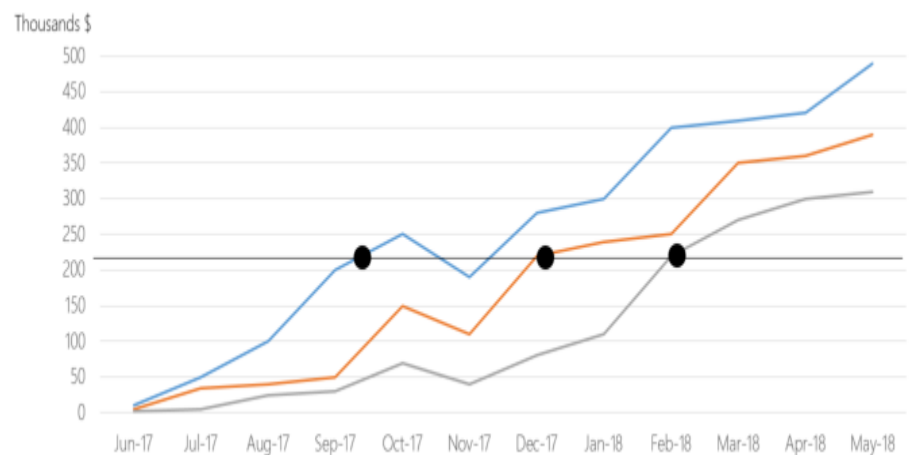

Fig. 14. Optimistic, Moderate and Pessimistic break-even scenarios.

the pessimistic scenario, the break-even point is only reached after the full commercialization of the idea which is completed with the IOS App release.

Pilot Case Study

At the moment, AMANDA team is conducting three different Pilot Case Studies. The first one is in close collaboration with Arsakeia Schools (www.arsakeio.gr) and Lexicon Schools (http://www.lexicon-edu.gr/). Forty-three children are engaged in testing AMANDA application monthly, providing us with the necessary data and feedback to adjust our proposals to their exact needs. Supported by psychologists and educators specialized at bullying (i.e., Stefanos Alevizos and Nancy Pilona), providing us with the appropriate guidance in psychology matters and the SPBTU of AUTH with the Research and Development (R&D) requirements. The initial results are very promising, as the empathy and self-confidence and awareness have been increased across the use of AMANDA's rooms (see Fig. 15). The second pilot case study aims at investigating the effect that AMANDA has on people's empathy, self-confidence, and awareness on the phenomenon of bullying with a one-time-only experience. This study took place in the "81th International Fair of Thessaloniki", and two events organized by the Aristotle University of Thessaloniki (AUTH). Almost 3000 people used and tested AMANDA for 10-15 minutes, where they were able to play a game of guessing people's emotions (raise of empathy), watch a bullying incident from the perspective of the bully, the bystander and the victim (raise of empathy, awareness and self-confidence) and to watch a 360 video where the user observes a bullying incident that is taking place inside a school (awareness). The clear majority of the users felt that they were inside the incident and tried to make that stop. The fact that they didn't manage to change the course of the story made them understand that they should always stand up to bullying and make it stop when such insides are occurring in their environment. The results of that pilot case study are not presented since the research on these data has not finished yet. The fact that we have to deal with big data sources and provide biometrics and behavioral features from correlated or uncorrelated, submerged in different types of noises data drives us checking the results with lengthy processes in order to assure the Quality of the services. The 3rd pilot case study is presented in the Research Topic.

Fig. 15. Mean values of empathy, awareness and self-confidence across 43 students testing AMANDA, showing evident increasing trend after the interaction within AMANDA rooms.

Fig. 16. (Top) Student testing AMANDA during the first pilot case study in Arsakeia High Schools. (Middle) Children and Adults testing AMANDA during the second pilot case study in the "81th International Fair of Thessaloniki". (Bottom) Student watching bullying incidents, while being measured with an EEG, during the third pilot case study.
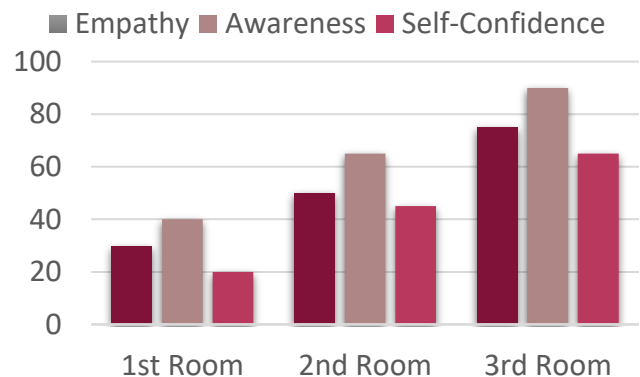
Research

In addition to the development of the application the AMANDA team considers essential to continue research on the issue. This summer, an experiment was conducted with the use of the electroencephalography (Clinical Geodesic EEG System 400 (256 Channels)) where the subjects were submitted into viewing two-dimensional and three-dimensional videos containing bullying and non-bullying scenarios. Out of this research a strong correlation was found between watching bullying scenes and brain activity (especially at ERPs N170 & LPP), while this correlation seemed to be stronger when watching content through the VR headset (Fig. 17).

Furthermore, the members of Team AMANDA are currently working on their thesis, investigating further the correlations between bullying incidents, the brain activity, and biometrics. Advanced signal processing techniques and machine learning algorithms are two of the main ingredients for our research, while all the research conducted adheres to the standards and is supported by the SPBTU (Signal Processing and Biomedical Technology Unit), department of Electrical & Computer Engineering, Polytechnic School, Aristotle University of Thessaloniki.

AMANDA, remaining faithful to the importance of research, has submitted a proposal for the PM07_2017 Horizon call with the aim creating a mixed world-based behavioral analysis environment, incorporating real, virtual and augmented reality, for capturing the changes in empathy and self-esteem levels when the children interact (alone or collaboratively) within a gamified and dynamic empathy museum, guiding them to personalized stimuli that increase empathy (bully), self-esteem/confidence (victim) and bullying awareness (bystander).

Fig. 17. Results of the third pilot case study. A strong correlation was found between watching bullying scenes and brain activity, while the correlation seem to be stronger when watching through VR.

Expected Impact

AMANDA is a key research and innovation contributor, which lays the foundation for significant opportunities to demonstrate the creation of new personalized behavioral health interventions fit for global scale up , to strengthen the research of our academic community, and primarily, to benefit society and our youth through improved and sustained health during development. AMANDA provides a new holistic ICT-based, gamified behavioral analysis approach for capturing bullying tendencies and provides ICT-based interventions to combat bullying in an innovative and effective way. AMANDA will deliver on the following expected impacts: **Micro-level: Individuals:** The young individual is at the center of the AMANDA ecosystem, as an active participant of the AMANDA community and a contributor to the behavior detection initiative who undertakes the support and care via the ICT-based AMANDA intervention. **Meso-level: Social Ecology (school environment, family relations and social engagement with peers) and Care systems:** Though most youth are physically, emotionally, and socially healthy, a large percentage of children and adolescent population meets the criteria for a lifetime mental health issues that can be accompanied by severe emotional, but also by social dysfunctions. **Macro-level: Wider society:** Central to AMANDA is the provision of social interaction, peer support and peer mentoring with individuals who are experiencing similar challenging situations.

Collaborators

In the following table (Fig.18), a catalogue with AMANDA's main supporters/collaborators is depicted. During its journey, AMANDA had the pleasure and honor to collaborate with organizations, private and public schools, enterprises all over
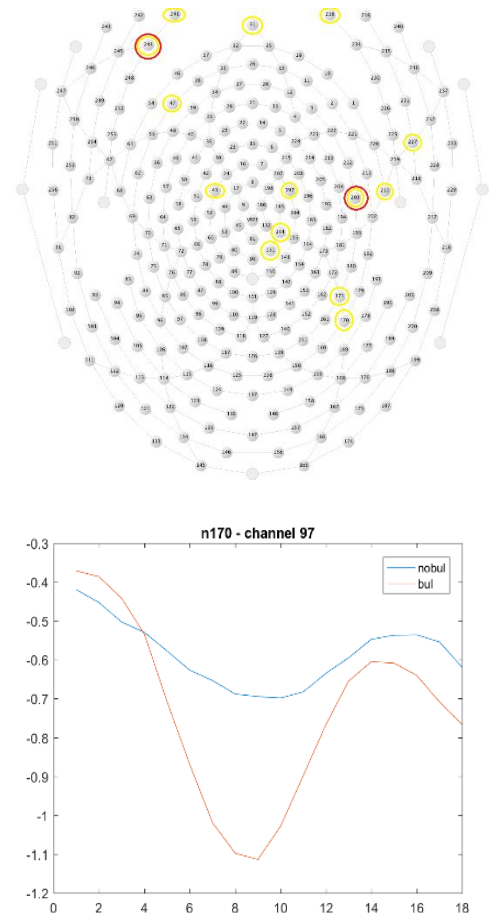
the world. Non-Governmental organizations like the "European Antibullying Network" and "The Smile of the Child" provided us with valuable support on children's behavior, anti-bullying theoretical material and practices and psychology results. In addition to this, Microsoft has supported AMANDA in a variety of ways by giving us the necessary technical and technology equipment, which is crucial for the development of the project, financial support for our first expenses in order to be able to complete the pilot case studies and legal support for filing a patent in the U.S. Patent Office. A lot of private and public schools were really engaged in testing our application in order to provide us useful feedback for making AMANDA great for every child, every educator and every psychologist. Finally, the most important collaboration for us is the one with Amanda Todd Legacy. Amanda Todd Legacy is a community that was created by Amanda Todd's mother, Carol, after her daughter took her own life. It is really important to have the moral and mental support by Carol, because in our most stressful and heartbreaking situations she was there to remind us of Amanda and give us the strength to continue in order to get humanity more close to combatting bullying.

The Smile of The Child	Non-Governmental Organization	Greece	Child's Rights, Anti-Bullying
Arsakeia Schools	Private School	Greece	Education
Lexicon Schools	Private School	Greece	Education
Microsoft Hellas	Enterprise	Greece	Technology
Microsoft Canada	Enterprise	Canada	Technology
Microsoft	Enterprise	U.S.A.	Technology
Amanda Todd Legacy	Non-Governmental Organization	Canada	Anti-Bullying
WE Movement	Non-Governmental Organization	Canada	Volunteering/Events
European Antibullying Network	Non-Governmental Organization	Europe	Anti-Bullying
Aristotle University of Thessaloniki	University	Greece	Education, Research
Artecitya	Non-Governmental Organization	Europe	Volunteering/Exposition
Signal Processing & Biomedical Technology Unit	Laboratory	Greece	Research
HELEXPO	Enterprise	Greece	Exposition
32th High School of Thessaloniki	Public School	Greece	Education

Fig 18. (Top) Table of AMANDA's main collaborators. (Bottom-Left) Team AMANDA with the president of "The Smile of the child" and the "European Antibullying Network" during the second pilot case study in the "81th International Fair of Thessaloniki". (Bottom-Right) Team AMANDA with "Amanda Todd Legacy" founder, Carol Todd celebrating for winning the Imagine Cup Competition in Seattle, U.S.A.

Traction to date

The story of Team AMANDA tracks back to September 2015 when it was originally formed. By February 2016, the first demo of the application was released and pilot case studies started at Arsakeia schools and Lexicon schools. At April, we participated at the Greek Finals of the Imagine Cup competition at which we received the first place and progressed to the international semifinals. It was at the end of June when AMANDA conducted the research with the use of the electroencephalography, while a few weeks later we were accepted to the Microsoft Patent Program, a program aimed at funding the filing of a U.S. patent. At 28th of July AMANDA won the World Citizenship category of Microsoft Imagine Cup competition at the world finals. With the return of the team in Greece, a second round of case study started where the application reached almost 3000 people. At the same month, the patent was filed and the team, sponsored by the same program, traveled to Atlanta for a technology event (Microsoft Ignite). Less than a month later, AMANDA was invited to speak to WE DAY Toronto in front of 20000 youngsters with the aim of informing them and inspiring them of the ideals of the team. There, AMANDA was offered a Microsoft HoloLens device as a developer device that could further improve the impact of the Augmented Reality part of the AMANDA ecosystem. Finally, AMANDA has made it to the second stage of a national innovation competition organized by the "National Bank of Greece" which will take place at spring 2017.

Fig 19. *Team AMANDA discussing with President of Microsoft Canada, Janet Kennedy, about using tech for good inspiring 20.000 children and teenagers.*

How could you take this further?

AMANDA is a revolutionary system aiming at providing integrated solutions to the basic problem related with bullying, i.e., detection and intervention. Using cutting-edge technology, AMANDA provides a holistic approach to the bullying problem by organizing a supportive community, providing information and engagement to its members towards a bullying detection and intervention initiative. It emphasizes on personalized and self-managed confrontation of the phenomenon, while at the same time, provides psychologists and educators with an invaluable tool, so as to contribute to the elimination of the phenomenon from a world citizenship perspective. Updates and improvements of the current solution include: *Cross-case testing and evaluation* of the feedback from the target group, regarding the expandability and functionality of AMANDA, gained through ongoing contact with children, psychologists and educators at Arsakeia and Lexicon Schools as well as "The Smile of the Child", along with the already established collaboration with European Antibullying Network which spreads all over Europe. *Further increase of the interventions*, by realizing a multiplayer platform so as to maximize the gamification features. *Further customization of tasks and scenarios* to personalized behaviors. Last but not least, the AMANDA will be also developed in **Microsoft Hololens**, once it is delivered to the team members.

AMANDA Team has made a considerable work towards the development and realization of AMANDA project. So far, the whole project has been designed and an important part of it has been realized. Given the complexity and the importance of the addressed problem, implementation issues, evaluation procedures, testing, and optimization are still under consideration. In the near future, a prototype is expected in a fully operational mode.