División Académica
de Ingeniería

WORKING PAPER SERIES

POCKET CLASSROOM

MOBILE VIDEO GAME DEVELOPMENT FOR EDUCATION

Pocket Classroom:
Mobile Video Game Development for Mobile Education

Mexico City, 2020

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ABSTRACT

The study confirms that video gaming and mobile technology combined are powerful tools for education purposes.

Considering the evidence, this analysis proposes the implementation of the Pocket Classroom, a teaching and learning technology-based strategy that refers to the use of video games in the educational process through mobile platforms with a reversed data billing scheme. It also provides public policy guidelines to improve the traditional teaching/learning mechanisms at schools.

The study finds that:

1. Video gaming is an important tool for education purposes, as it helps to improve skills such as collective intelligence, creativeness, and human/computer communication.
2. Artificial Intelligence, Virtual Reality and Augmented Reality are important tools that make the most of the educational potential of video gaming, by making the learning-teaching process more efficient.
3. Evidence suggests that a mobile platform is necessary for video games to play a better complementary role in education.
4. Mobile devices have significant adoption patterns in terms of policy inclusion.
5. Connectivity is still a major challenge. For this, a reverse data billing scheme is proposed.
6. The technology-based education policies in Mexico have considered the teaching training side, the delivery of devices, the implementation of ICT-equipped classrooms, and the proliferation of content. Nevertheless, they have been implemented not necessarily in an articulated manner and, at an enormous cost, with no relevant impact and lack of continuity: an innovative and cohesive policy is needed.
7. The pandemic brought public efforts to set up a distance education strategy which lack of a mobile component.

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INTRODUCTION

We are on the verge of harnessing video game platforms beyond the gaming experience itself. These entertainment tools are increasingly becoming an enabler of professional skills and educational competences, fundamental inputs for solid professional careers and productivity perspectives for individuals, more so in a skewed opportunities country like Mexico.

The main hypothesis of this white paper is that video gaming and mobile technology combined are powerful tools for education purposes.

Therefore, the analysis hereby presented proposes the implementation of the *Pocket Classroom* learning tool, a concept that refers to the use of video games in the educational process through mobile platforms. It also explores potential public policy design to improve the traditional teaching/learning mechanisms at schools.

This document begins with a review of empirical results that shows how improvement of video games and skills are related. It follows with a section describing relevant educational video game design characteristics.

There is evidence indicating that plenty of video game characteristics make them more prone to complement education processes than other tools. Considering the impact of those characteristics, it is relevant to identify the specific video gaming features that are optimal for education purposes, this is explored in the second section of this document with special emphasis on Artificial Intelligence (AI), Augmented Reality (AR) and Virtual Reality (VR).

The following section describes the social gaming patterns in Mexico such as intensity, uses, and preferences, and therefore the target for an educational public policy strategy.

The fourth section reviews some ICT-centered education policies and initiatives designed and implemented in Mexico. Most of them were focused on device provision for students as well as on digital content generation.

The use of technology on education processes in Mexico has not been able to reach the expected social impact, when measured by indicators like the number of people, or the development of XXI century skills.

A conclusive recommendation to introduce video gaming as a powerful learning-teaching tool for education in Mexico is reached at the end of this paper.

VIDEO GAMES AND SKILLS ENHANCEMENT REVIEW

Sometimes video games have risen concern due to their association with distraction, leisure, stereotyping behavior and, even with obesity and violence.

Nonetheless, video games can represent a potential tool in enhancing educational processes. To this end, a review regarding available empirical evidence that correlates video games and skills development with personal improvement is carried out, so we can have a comprehensive vision of the benefits of this tool.

Alongside a review of the history of video games in the educational research, Kurt Squire made an interesting stand against traditional gaming concerns. Squire begins by reviewing how some studies have failed to prove a causality relation between aggressive behavior or poor school performance, while he posits the importance of environmental design in video games as a tool to develop collaborative skills in gaming. Regarding the gender stereotype creation, Squire lists several video games showing strong women role models and how video games can lead to an interest on technological matters.[1]

Technological revolution has proven that almost every job related with physical capabilities can be done by machines. Productive chains are constantly optimized looking for more automation and less human dependence. But the most valuable asset for a person in a technological environment is creativity.

Back in 2004, by surveying 2500 young professionals, John C. Beck and Mitchell Wade found that "those who described themselves as regular gamers were more creative, ambitious, and even more optimistic about their abilities."[2]

Likewise, educators are concerned about the development of updated twenty first century skills in the next generations, as future leaders are expected to be versed, multitaskers, negotiators, creative, decision makers, and digitally aware and prepared. By requiring deep collaboration among players, multiplayer games involve collective

[1] Squire, Kurt, *Video Games in Education*, (Cambridge, 2003), pp.2-16.

[2] Beck, John and Mitchell Wade, *Got Game: how the Gamer Generation is Reshaping Business Forever*, (Boston, 2004), pp.4-14.

intelligence, which is also a valuable skill expected from future labor force[3]. Thanks to video games, children are constantly confronted with new situations, stimulating their minds and building useful abilities for networking.

Multiplayer gaming also opens a whole new environment to acquire knowledge by means of peer-to-peer learning. Nowadays, for instance, infants can learn by interacting with their friends or siblings, no matter the moment in time or their actual location around the globe, opening opportunities to redesign the map of knowledge, and to improve horizontal learning by social interactions through video games.[4]

Video games not only improve collaborative skills and promote equal gender roles. They also improve physical response suggesting that gaming may constitute a strategy for training staff to improve emergency reactions or very detailed procedures. According with Mark Griffith[5], the positive effects of video gaming have been realized since 1980, and the results are consistent showing that computer games, no matter the type, improve reaction times, and boost hand-eye coordination.

Achtman, Green and Bavelier explore how action video games are interesting tools for visual rehabilitation since a training regime showed improvement of visual attention and basic visual processing. [6] These results show that gaming does not only promote and improve physical skills, but it also helps recovering them.

On the other hand, Griffith points out video gaming as an enhancer of players' self-esteem. Although this is not a competence or skill itself, this emotional state may impact on the productivity of individuals and their willingness to acquire knowledge.

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[3] A., Annetta, Leonard, V*ideo Games in Education: Why They Should Be Used and How They Are Being Used*. (Ohio, 2008), pp. 231-235.

[4] Green, Hannah, and Celia Hannon, *Their Space: education for a digital generation,* (London,2007), pp.48-50.

[5] Griffiths, Mark, "The Educational Benefits of Video games", *Education and Health*, vol. 20, No. 3, (UK, 2002), pp. 47-49.

[6] Achtman RL, *Green CS, Bavelier D.* "Video games as a tool to train visual skills", *Restorative Neurology and Neuroscience*, (2008), pp.435–446.

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Sometimes acquiring programming skills suggests learning from coding literature, basic tutorials on internet, and online courses, these seems to be a good option to learn new computer languages, nevertheless there is an alternative: games specifically designed for improving programming skills. In the market there are a range of videogaming-based resources that develop coding skills or promote code-related skills among children.[7] By using coding games, it is possible to provide or improve programming skills.

It is important to highlight that according with Phac, et al., programming at high school education levels can be part of the curricula. At elementary school levels, on the other hand, this type of education should focus on developing skills and knowledge related to coding capacity; covering topics like: algorithms, logical reasoning, predicting and analyzing, decomposition, patterns, abstraction, and evaluation.[8] Infants should also develop familiarity with computer-human interactions, recreation of scenery and motion, and computer performance and characteristics.

Considering the above, it is possible to highlight specific human skills that videogames enhance and are desirable for education purposes:

- *Coding*
- *Creativeness*
- *Collective intelligence*
- *Network creation*
- *Horizontal learning*
- *Physical response improvement*
- *Digital era communications*

[7] CodeMonkey provides education resources that provide children with coding skills, and also teaches how to code in programming languages such as CoffeeScript and Python: https://www.codemonkey.com/

[8] Djurdjevic-Pahl, Aleksandra & Pahl, Claus & Fronza, Ilenia & El Ioini, Nabil. (2017). A Pathway into Computational Thinking in Primary Schools. Lecture Notes in Computer Science. 10108. 165-175. 10.1007/978-3-319-52836-6_19.

Although this literature review shows that video games are a powerful tool to develop or improve skills, it does not end the discussion towards their impact on the user, i.e. specific social behavior or emotional reactions.

For these reasons, we further explore in this paper what video game design features are more relevant for developing human capital skills

VIDEO GAME DEVELOPMENT FEATURES RELEVANT FOR EDUCATION PURPOSES

This section explores some of the video game design characteristics that are helpful to complement education processes. It is found that implementing Artificial Intelligence, Virtual Reality, Augmented Reality, Cloud Computing, and Computer/human interaction, in video games is an optimal decision considering its potential impact on education.

ARTIFICIAL INTELLIGENCE

In the process of including new technological advances in the educational process, there are a few methods that stand out. Artificial Intelligence (AI) is a highly advanced technology that obtains information from the real and digital world through sensors or objects connected to the internet. Being the main purpose of AI the use of algorithms that analyze the referred information and, the machines will answer, learn and adapt in the way humans do.[9]

This characteristic of AI represents a benefit for its use on the educational process, as it allows content to be personalized depending on each student's needs and preferences. The hope of including AI on education is that it will help to fill gaps in learning and teaching, through more efficient processes and personalization, allowing teachers to have more resources and freedom in teaching. In this way, AI works as a complement in education rather than a substitute for teachers or other traditional methods.[10]

It is reasonably expected that with more developed AI, machines will be able to recognize students' facial expressions while solving a task, and if they are struggling with it; so machines could end up redirecting students to more appropriate targeted lessons.

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[9] The Social Intelligence Unit, "Inteligencia Artificial en lo Público" in *U-Gob*, (Mexico, 2019), available at: http://bit.ly/3158UAV

[10] Marr, Bernard, "How is IA used in Education, Real World Examples of today and a Peek into the future" in *Forbes*, (USA,2019), available at: http://bit.ly/2VpRSeA

Another perk of using AI on education consists in the internationalization that it allows. It makes global classrooms available: a child in Singapore can listen to a math lesson in Peru. A tool that proves the benefit of this characteristic is Presentation Translator, which is a free plug-in for presentations that generates subtitles in real time for what the teacher is saying.

This, apart from allowing children in different parts of the world to take a class, allows ill or disabled children to attend the class from home.[11] The AI-powered recognition and translation services allow students to hear or read what's being said in their native language.

The Presentation Translator adopted the new educational vision of including Machine Learning (ML) to introduce AI driven features in its products and help teachers and students in the educational processes, and ensure that every student has access technology in a way that improves their learning.[12] The free-of-charge Seeing AI app, for visually impaired, reads the text aloud to the student by taking a photo of it with a smartphone, and it can also describe a scene by taking a picture of it with the app. These apps are great examples of how AI helps internationalize and maximize the scope of education, being as well a tool for inclusiveness and education gap reduction.

Diverse learning digital platforms are already available in commercial markets, to deliver personalized lessons to each student, depending on their knowledge level; how they feel regarding the content; and how long do they take to solve the tasks they are assigned to. This way the platform adapts the content and feedback to the student's needs.[13]

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[11] McNeill, Sam, *Artificial Intelligence in the Classroom*, Microsoft Education Blog, (USA, 2019) available at: http://bit.ly/2IAad3g

[12] *Idem.*

[13] Delgado, Paulette, "La Inteligencia Artificial llega a 700 escuelas en Bélgica", *Observatorio de Innovación Educativa*, (Mexico, 2019). Available at: http://bit.ly/35jR6nT

It is convenient, at this point, to make a distinction between Virtual Reality (VR) and Augmented Reality (AR). While Augmented Reality combines technological tools that project virtual images to real objects, Virtual Reality involves a complete immersion in a virtual environment. In recent years, researchers and education experts have been trying to integrate these tech tools in classrooms, not only at the college level, but also from elementary to high school stages, because children can relate with gadgets and consoles from a very young age. In a way, video games have been the main path in which new generations have developed mental mechanisms to take advantage of the coming future.

In a world where people have too many distractions and stimulus, and where social media allows cyber bullying to reach children's lives even when they are at home, Augmented Reality has proven to be useful even in an emotional space. Researcher Tsung-Yu Liu has discovered that AR can improve student motivation in the learning process.[14]

Iulian Radu, a researcher from Harvard University, has focused on evaluating how Augmented Reality applications can impact learning capabilities and cognitive development. His findings show positive impacts, such as an increase in content understanding, long-term memory retention, and also an improvement in collaboration and motivation.[15]

AR also has proven to be effective in enhancing visual capabilities and creative content creation.

Marc Ericson C. Santos, along with Angie Chen, Takafumi Taketomi and several other scholars applied a meta-analysis in the dimensions of display metaphors and evaluation techniques. The authors conclude that AR can improve contextual and vision-haptic

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[14] Liu, Tsung-Yu and Yu-Ling Chu, "Using Ubiquitous Games in an English Listening and Speaking Course: Impact on Learning Outcomes and Motivation". *Elsevier*. (Taiwan, 2010), p.630.

[15] Radu, Iulian, *Augmented reality in education: A meta-review and cross-media analysis*, (Boston, 2014), pp.1-5.

visualization. This finding is supported by existing educational theories, such as multimedia and experimental learning, and animated vision theory.[16]

Using an extensive survey about research and educational capabilities back in the 1990's, Youngblut tried to answer the question about how effective Virtual Reality could be in enhancing the kindergarden environment for children. The researcher found that VR is quite effective for students with special needs. The role of the teacher changed, and through the use of VR, they became facilitators rather than traditional educators. In the survey, students showed that they enjoyed using VR and would like to develop their own virtual world. Finally, teachers who responded to the survey said that they would likely use VR technology if it was available and, of course, affordable.[17]

Another study states that, by simultaneously assimilating symbolic and experimental information, VR immersion improves learning and comprehension[18]. It's natural to relate these findings with video games and their impact on education. When video games were created, VR was not as available as today. Video games can be interpreted as a partial immersion to Virtual Reality.

William Winn, a researcher from the University of Washington, states on his paper "A conceptual basis for educational applications of virtual reality" that the experiences acquired by VR usage cannot be obtained in any other way in formal education[19] Also, VR immersion in first-person non-symbolic experiences, particular and individual experiences, can help students to get a better relationship with study material.[20]

VR also allows students with very particular abilities to get more practice hours without any physical or material repercussions. By repetition and reiteration using Virtual

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[16] Ericson C. Santos, Marc, Angie Chen, Augmented Reality Learning Experiences: Survey of Prototype Design and Evaluation. *IEEE Transactions on Learning Technologies*, (Nara, 2014), p.18.

[17] Youngblut, Christine, *Educational uses of virtual reality technology*, (Virginia, 1998), pp. 103-105

[18] Bowman, Doug, Larry Hodges, Don Allison, & Jean Wineman, "The educational value of an information-rich virtual environment," *Presence: Teleoperators & Virtual Environments*, (USA; 1999), p. 320.

[19] Winn, William, "Conceptual Basis for Educational Applications of Virtual Reality". *Human Interface Technology Laboratory*, (Washington, 1993), pp. 1-5.

[20] *Ibid, p.10.*

Reality immersion, tasks that are difficult to experience through the learning process can improve drastically in real life[21]. By accessing to VR simulations emulating very particular and not common to see cases in real life, students will be able to practice in such environments, empowering future workers on specific capabilities and cognitive abilities.[22]

Students with learning disabilities can also be positively affected by VR technology. By learning inside a virtual environment, learning transfer problems can be minimized.[23]

Virtual and Augmented Reality have already spread in mainstream culture with an astonishing acceptance, so much of their contribution to science and education is already palpable.

But there is so much yet to come related to the application and studies measuring the effects of these tools. The biggest enemies of VR and AR applications have been always budget related, nevertheless the value associated with the development of the abovementioned skills offsets the cost of implementing these technologies, whenever they allow people with disabilities to improve human capital and enhance creative production and virtual training.

[21] Mantovani, Fabrizia, *VR learning: Potential and challenges for the use of 3D environments in education and training*, (2001), pp.12-15.

[22] Chou, Chiu-Hsiang., *The effectiveness of using multimedia computer simulations coupled with social constructivist pedagogy in a college introductory physics classroom*, (Boston, 1998), p.10.

[23] Freina, Laura, Michela Ott, *A Literature Review on Immersive Virtual Reality in Education: State of The Art and Perspectives*. (Bucharest, 2015), pp. 1-15.

VIDEO GAMES MARKET IN MEXICO:

DEMAND SIDE AND MOBILE ADOPTION TRENDS

During the first decades of the video games market development, the industry targeted people under 18 years old, whose only way of access them were fixed consoles. Nonetheless, the growth of access devices and business models since internet and smartphones arrival, enabled a broader range of video games platforms boosting a radical change in consumption patterns.[24]

This progress allowed the emergence of two gaming schemes: consoles (fixed and mobile) and other mobile devices (smartphones and tablets).

Traditionally, consoles were the only available platforms, but massive entry of smartphones in Mexico, which reached 111.1 million devices in use by the end of 2019 boosted the access to "pocket consoles".

The reduction in the price of smartphones made the video game market affordable to population segments that were distant to this kind of entertainment. In terms of age, both Millennials and Generation Z cohorts account for the most intensive adopters when compared to other generations. An important characteristic of this cohort is that they are students, which means they are an important social group for implementing and adapting video gaming as an education tool.

Considering the latter, mobile video gaming stands out as a remarkable opportunity to build up an education strategy based on the use of technology among the population in their formal education years despite their socioeconomic condition.

[24] The Competitive Intelligence Unit, *Industria de Videojuegos: Un cambio (In)esperado* (México, 2019). Available at: http://bit.ly/2NLzYkg

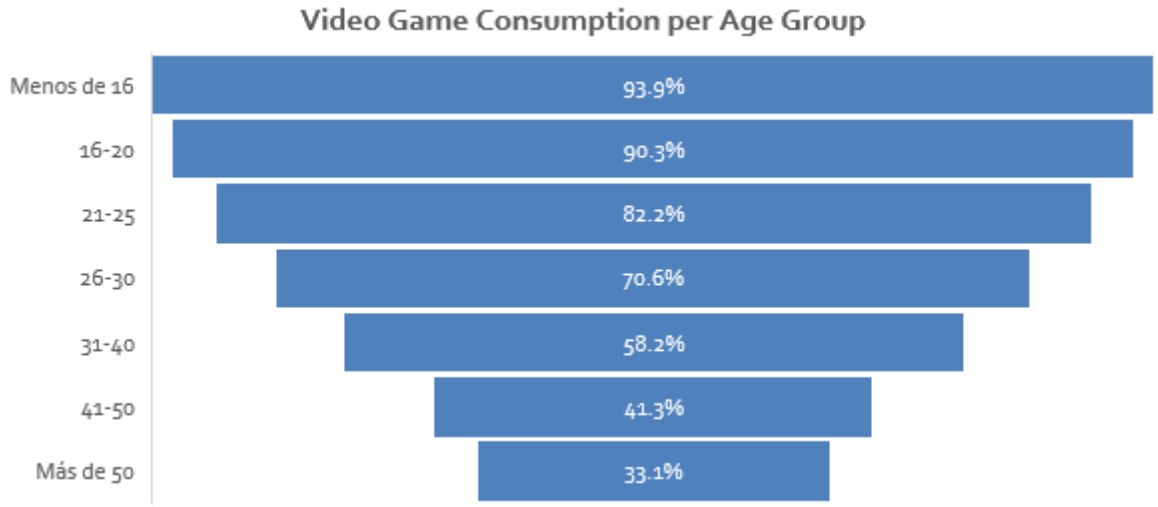
DEMAND SIDE

This part presents some results of a representative survey to quantify the video game industry in Mexico and its consumption patterns[25]. The relevance of this information relies on identifying a potential social group where a gaming education strategy could have a broader impact.[26]

Currently, Mexico accounts for 72.3 million gamers, which means 5.2% more than the previous year representing almost half of the Mexican population. Out of the total, 21.6 million are under 16 years old, while 10.1 million are between 16 and 20 years. Therefore, 93% of Mexicans considered as Generation Z (under 20 years old) are video game users.

68% of the population between 21 and 40 years are gamers, which accounts for 26.4 million users, while 41% of people between 41 to 50 years enjoy gaming, which means an additional amount of 6.4 million users.

On the other hand, 8 million Baby Boomers are gamers, namely 33% of this generation which includes people older than 50 years.



Source: Análisis y Dimensionamiento del Mercado de Videojuegos en México, The Competitive Intelligence Unit, 2019

[25] The Competitive Intelligence Unit, *Industria de Videojuegos: Un cambio (In)esperado* (México, 2019). Available at: http://bit.ly/2NLzYkg

[26] The Competitive Intelligence Unit, *Análisis y Dimensionamiento del Mercado de Videojuegos 3Q19* (México, 2019).

Even though the study focuses on people on scholar age, it's also noteworthy pointing out that according with the figures above, there is a negative correlation between age and gaming: the older the people, the less they tend to play video games. This phenomenon raises questions not only regarding the limitations of older generations to adopt this tool, but what can be done to provide continuous education using video games to this age segment. This may be the subject for another study.

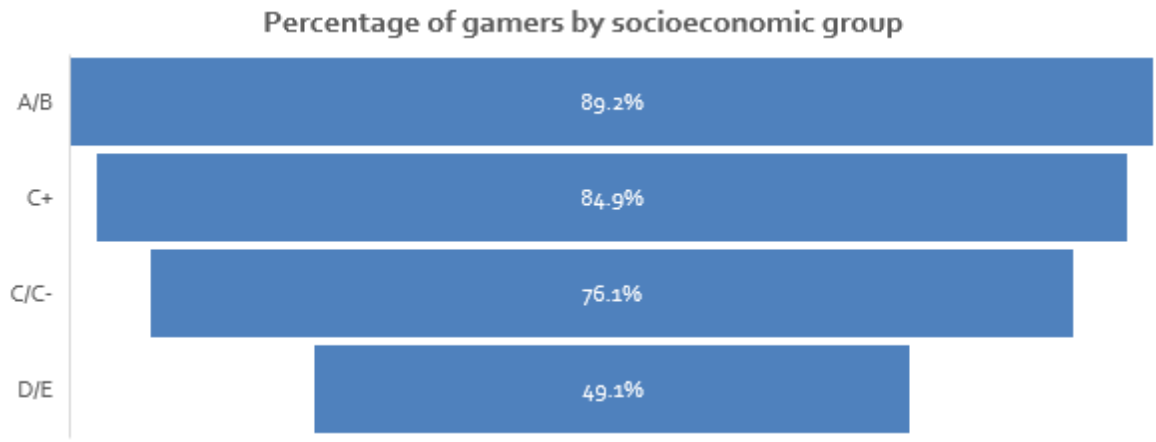
Not only age impacts the interest on video games, gender is also an issue. The analysis has found that women and men have different adoption patterns: while 75% of men are gamers, this indicator is 54% among women, a gap that accounts for 21 percentage points. Considering that almost half of the gamers are in non-productive or low-income age (20 or less years), it seems that the adoption gender gap is not explained by individual's income, but by social patterns that tend to associate video games with masculine activities. This needs special attention since any education strategy applied to this demographic structure (men with higher adoption than women) needs to consider a gender perspective that prevents unequal access.

Regarding adoption among socioeconomic groups, significant differences were found. Gamers in the top socioeconomic group (A/B[27]) accounted for an 89% penetration, while there were 85% in the mid-top (C +[28]) group.

[27] This group includes households where the family head has professional studies, and they have internet access. Their primary investment is in education services and they use a smaller fraction of their spending in food compared to other levels.

[28] C+ group households tend to have one or more transportation vehicles; they also have fixed internet access and one third of their spending is in food.

The mid-low level (C/C-[29]) registered a 76% indicator. On the other hand, the low level (D/E[30]) segment, having the highest growth rate in the last year, reached a penetration of practically half of its group (49%).



Source: Análisis y Dimensionamiento del Mercado de Videojuegos en México, The Competitive Intelligence Unit, 2019

As a result, video games as an education tool has a lot of potential among Generation Z according with their consumption patterns, nevertheless gender and socioeconomic gaps are topics that need to be addressed.

Introducing video games in the teaching/learning process suggests not only the implementation of a strategy among the youngest generation, but the construction of a consistent and articulated public policy in basic, secondary, and even tertiary levels that consider the public education principle known as universal. The conclusions in the fourth section of this paper will help to design public policy guidelines taking advantage of the "pocket classroom" vision.

[29] C and C- groups tend to spend more on food compared to other services and products including education. 73% of these households in C level have fixed internet access, this indicator is 47% in C- level.

[30] These groups show the lowest adoption of fixed Internet and they spend important amounts on food. The family heads tend to have low schooling levels, and their education investment represents the smallest fraction in their spending scheme.

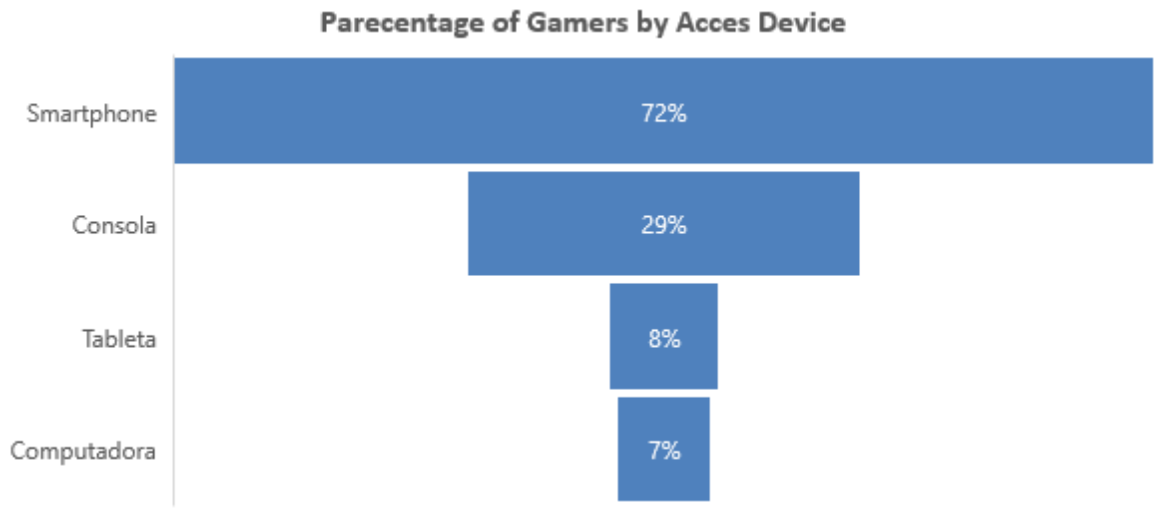
Mobile technology is changing lives and industries, particularly with the emergence of smartphones in the first decade of the XXI century. This innovation allowed people to have connected computers to internet in their hands anytime and anywhere.

A range of mobile solutions provides support in medical consultation processes in public and private healthcare systems, new education models are inserting innovative strategies to develop knowledge and skills, and financial markets are facing new competitors that take advantage of mobile connectivity. An entire economy is growing at considerable rates around data creation, and ubiquitous computing and connectivity.

Video games are not the exception to the rule. Through the usage of mobile technologies, people complement their gaming routines, and have access to affordable versions of their console games.

The use of smartphones as pocket consoles has had an important adoption dynamism. Let's consider that smartphones penetration in Mexico is reaching 100%. There are 111.1 million smartphones in use, which gives people potential access to millions of free and pay gaming applications.

From the total number of reported gamers, 72% use their smartphone as a console, which represents 52 million people.



Source: Análisis y Dimensionamiento del Mercado de Videojuegos en México, The Competitive Intelligence Unit, 2019

Behind smartphones, there are fixed consoles with 29% penetration among gamers. Currently, there are 15.7 million households with at least one of these devices. This segment represents a different profile since they tend to allocate more funding to video game experience.

Gamers using tablets and computers to this end accounted for an 8% and 7% respectively, namely 5.8 and 5.1 million people using these devices for video gaming.

As mentioned in the beginning of this section, smartphones are devices that almost reach the adoption ceiling in Mexico. Their adoption is similar when segmented by gender and socioeconomic group.

Given the wide population penetration and transversal adoption, smartphones have an enormous potential to shrink the gender and socioeconomic gaps in the video game market, making them the optimal tool for a video game education policy.

It is important to consider that, as proposed in the section before, AI, VR and AR applications are desirable characteristics for videogames due to their impact on skills development. These applications require high-capacity devices so they can optimally perform.

Digital Gap and Reverse Data Billing

Today it is not enough for students to have access to smartphones and gaming-oriented content. Connectivity has become the backbone for accessing to information an educational content.

In contrast to the extended smartphone adoption pattern, Internet access remains to be far from universal.

In Mexico, an internet connection is only available for 56% of households[31], while 77 out of 100 people access internet through mobile services.[32]

This digital gap represents a major challenge to the Pocket Classroom strategy due to the higher number of households and people with no access to connectivity services.

Currently, there are internet access policies aiming at universal coverage in Mexico, such as the free internet access in public spaces strategy developed by the Ministry of Communications and Transportation (SCT by its acronym in Spanish). In 2019, the Ministry categorized 19,048 public sites as connectivity priority which "CFE Telecom Internet para Todos", a state-owned company founded in 2019, is supposed to service as part of their task to connect all public spaces. [33]

Also, there is a public-private effort known as the "Shared Network" deploying a wholesale telecommunications network which must provide coverage to 92.2% of the population. As reported, this network currently covers 50.18%.

These strategies are still insufficient for students since there are 62, 434 schools in basic and medium levels with connectivity requirements[34]. Therefore, alternatives must be provided.

The Pocket Classroom strategy promotes the use of reverse data billing schemes where students are provided of free of charge mobile internet service. These schemes work as toll free numbers for telephone calls where the person or the organization receiving the call is responsible for paying the service tariff.

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[31] Instituto Nacional de Geografía y Estadística, "Encuesta Nacional sobre Disponibilidad de Tecnologías de la Información en Hogares (ENDUTIH) 2019". Available at: https://www.inegi.org.mx/programas/dutih/2019/

[32] Instituto Federal de Telecomunicaciones (IFT), "Banco de Información de Telecomunicaciones". Available at: https://bit.ift.org.mx/BitWebApp/

[33] Secretaría de Comunicaciones y Transportes (SCT), "Programa de Conectividad en Sitios Públicos" (México, 2019). Available at: https://www.gob.mx/cms/uploads/attachment/file/515841/PROGRAMA_DE_CONECTIVIDAD_EN_SITIOS_P_BLICOS.pdf

[34] Ibid.

Because of progressiveness and social reach, the reverse data billing solution should benefit students from low income households using prepaid tariff schemes.

The progressiveness effect means that low-income household students will be the most benefited. Prepaid services users report a low average spending (3.8 dollars per month) and, therefore, a limited internet use. On the other hand, scope effect means that focusing on prepaid users will allow servicing an important portion of the students. Prepaid scheme accounts for 82% total lines.

As we know, in a traditional scheme, the students go to their schools. The reverse data billing scheme allows bringing school to the student, particularly those belonging to low income households. This scheme represents an opportunity for the public education system to amplify the impact and reach of their tele-education programs.

REVIEW OF TECHNOLOGY-BASED POLICY IN THE MEXICAN EDUCATION SYSTEM

This section explores the evolution and changes of technology-based education policy in Mexico since 1997 to 2016. Besides, it explores the current stagnation in policy and how efforts are focused on providing connectivity service to academic and education spots, as well as workshops in digital inclusion centers.

These programs, mostly operated by the Ministry of Education (SEP by its acronym in Spanish), are classified into four categories for the purposes of this document: equipped classrooms, a device per student, an integral model, and connectivity provision.

This classification is mostly based in the way students are provided with ICT-related equipment.

EQUIPPED CLASSROOM (1997-2012)

During the second half of the 90´s, the Ministry of Education introduced "Scholar Network" ("*Red Escolar"* in Spanish), a program intended to create technology-based classrooms equipped with computers, fixed internet access, and educational content.

The program was conceived as a network of students, professors, parents and other relevant members of the education community, all of them able to communicate through internet. Professors could track the modifications of academic programs while students received relevant content and information according with SEP´s programs[35]. Red Escolar targeted students from basic school programs and teacher-training.

After this program, in 2004, a new approach was adopted. Through Enciclomedia program, the Ministry of Education adapted content from student's free textbooks and teachers'

Red Escolar results:
3,000 schools participated between 2002 and 2004.
200,000 students participated in collaborative projects.

[35] Muñoz-Izquierdo, Carlos; Rolando, Magaña Rodriguez. "Un acercamiento a la eficacia de los programas del gobierno federal orientados a mejorar la calidad de la educación básica",en *Revista Mexicana de Investigación Educativa,* (México, 2009), Avialable at: http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1405-66662008000400007

textbooks to a digital environment[36]. Students from elementary school (fifth and sixth graders) and professors were beneficiaries of ICT-equipped classrooms and teachers' centers[37]. The program considered training processes for teachers to guarantee the correct appropriation of the Enciclomedia system.

The distribution of educational content was through compact discs whose information was installed in computers' hard discs, which implied that no connectivity was required to share content.

Although the program seemed to be integrally designed because it considered students and teachers' perspective as well as the installation of ICT equipment, the program ended up focusing on the provision of equipment and not in providing follow-up to the training sessions and proper assessment.[38]

Enciclomedia results:
Between 2005 and 2009, 11 million students serviced
126 thousand ICT-equipped classrooms

The next generation of technology-focused education policy was "Digital Skills for All". This initiative started in 2009 and continued the concept of ICT-equipped classrooms at elementary and high school levels and considered teachers' training and certification on ICT integration. This program provided high school education students with laptops, which constituted an important antecedent to the transition to a "device per student" policy

DEVICE PER STUDENT (2013-2015)

The "device per student" approach started with "Mi COMPU.MX" program which brought tablets for students attending 5th and 6th grades between 2013 and 2014. The tablets had pre-charged educational content and special software for students and

[36] Subsecretaría de Educación Básica y Normal, *Enciclomedia: Documento Base*, (México, 2004), available at: http://www.oei.es/historico/quipu/mexico/documento_enciclomedia.pdf

[37] The equipment consisted of computers with pre-charged contents, interactive blackboards, digitized free textbooks and projectors.

[38] Consejo Nacional de Evaluación. "Seguimiento a Aspectos Susceptibles de Mejora Derivados de las Evaluaciones Externas", en *Secretaría de Educación Pública,* (México, 2007). Available at: https://www.coneval.org.mx/rw/resource/Mecanismos_2008/SEP/DT_SEP_ENCICLOMEDIA.pdf

teachers. The program lacked training strategy for teachers, as well as technical support.[39]

At the same time the National Digital Strategy Coordination performed a pilot program in previously selected public schools in different points of the country. This program known as "Programa Piloto de Inclusión y Alfabetización Digital" (PPIAD) characterized for enabling good quality connectivity in the intervention groups and a proper assessment.

PPIAD results:
During the scholar year 2013-2014, 240 thousand tablets were delivered
During the scholar year 2014-2015, 710 tablets were delivered.

The initiative derived in the creation of a new area within SEP, explicitly dedicated to the introduction of a technology-based education policy: @prende Coordination.[40]

After the pilot program, the @prende initiative was implemented by delivering more tablets to elementary school students, most of them in 5th grade. The program innovation had cross platform content allowing students get more knowledge and appropriation capacity. The initiative had limited coverage since it only served 15 states.

@prende.mx results:
During scholar year 2015-2016, more than 1 million electronic devices were delivered.
63 thousand teachers were trained.

This initiative faced two main opportunity areas that prevented its success. First, delivering tablets in some non-connected schools caused a limited appropriation of the device's benefits. On the other hand, there was no selection criteria to determine the participating states.

[39] Gobierno de la República, "México Digital", *Programa @prende 2.0*, (Enero, 2018). Available at: https://www.gob.mx/mexicodigital/articulos/programa-de-inclusion-digital-prende-2-0

[40] *Ibid.*

TOWARDS AN INTEGRAL MODEL (2016-2018)

By 2016, SEP announced @prende 2.0[41], a comprehensive strategy which integrated the previous program. The strategy included teachers' training, digital content, equipment, connectivity, monitoring and assessment.

@prende 2.0 was designed to take advantage of devices already delivered during the deployment of past programs, therefore it focused on delivering content in digital platforms and training teachers. The installation of technology-enabled classrooms was planned, all of them connected.

@prende.mx 2.0 results:
2,600 digital resources available for students.
In September ,2017 the bidding process for digital services related to the program was cancelled.

The program recognized connectivity services for public schools as one of the key enablers to achieve the device's optimal use. The Coordination and the Ministry of Communications and Transport (SCT by its acronym in Spanish) through the México Conectado program made joint efforts to provide these services.

Three connectivity models were proposed by the Coordination as a result of a rage of pilot test performed with the

SCT and industry participants: connectivity only for the teacher's device, connectivity for 10 devices simultaneously, and connectivity for 30 devices simultaneously. These models considered different content appropriation levels and skills to develop. Although the initiative was comprehensive and tried to adapt experience from previous programs, the execution was limited due to budget limitations.

WHAT IS HAPPENING (2019-)

Currently, efforts to include ICT-based education policies are focused on providing connectivity through Internet para Todos program (a continuation of México Conectado

[41] *Ibid.*

program). During the first half of 2019, a bidding process took place to provide the service to 1,275 public spots, education centers among them.[42] As well, by the end of the first half of 2019 year, SCT reshaped the model of the 32 digital inclusion center which seeks promoting information technology-based training for people of different ages. The SCT certificates facilitators that are responsible for transferring knowledge in the digital inclusion centers.[43]

On the other hand, the @prende Coordination now is focused on training teachers, providing cybersecurity workshops and expanding the use of the online platform Mexico X.[44]

Currently, Mexico faces an important opportunity to implement a long-term ICT-based education policy. Previous experience shows that government agencies such as the @prende coordination, and universal connectivity policies are powerful enablers to boost an innovative education strategy that increases qualified human capital and boosts productivity and social development in a context of world stagnation.

This mentioned policy requires public investment, coordination between SCT and SEP to take advantage of previous experience, coordination with ICT industry and focus on next-generation skills, such as coding, creativeness, collective intelligence, and horizontal learning.

THE EDUCATION VACCINE

During COVID–19 contingency, the development of tele-education solutions has become more popular around the world, and Mexico isn´t left behind. The Ministry of Public Education (SEP for its acronym in Spanish) is taking action by settling the program "*Aprende en Casa*".

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[42] Compranet's File 1933694 – High Capacity Internet Services.

[43] Secretaria de Comunicaciones y Transportes (SCT). *Centros de Inclusión Digital Inician Nuevo Modelo de Desarrollo y Formación de Habilidades* (May, 2019). Available at: https://bit.ly/2tOkYuU

[44] Coordinación General @prende.mx. *Alcances de la Coordinación General de @prende.mx durante el 2019* (December, 2019). Available at: https://bit.ly/2RwYjMH

This is an eLearning strategy that provides access to public education from home, offering a platform focused on basic education levels from kindergarten to high school.

Among the strengths of this program, there is, the use of both traditional (non-digital) and digital channels. From TV broadcast programs to websites, a variety of tools have been created to overcome the boundaries imposed by the quarantine, reaching the most of students and educational profiles.

For starters, this strategy provides a website[45] [46], where the students are given a weekly program which is grade and subject suited. This program includes daily homework and complementary material such as videos, tips, podcasts, videogames, etc.

This program aims at creating a support system that optimizes this distance learning process, the parents' role and its engagement are fundamental. They are guided by letters[47] on how the educational process should be depending on the level of their child.

Additionally, whenever parents and students are having trouble, they can reach out to a teacher through a phone call[48] or they can also send their questions via email[49] from Monday to Friday.

On the other hand, an ally for the diffusion and impact of the "*Aprende en Casa*" strategy has been mainly the public broadcasting service: Televisión Educativa, Canal Once, and radio broadcasters. Together they reach 94% of households through open and paid television and radio programs- which are offered in fifteen indigenous languages, with various content aimed at students from kindergarten to high school.

Each broadcasted session is recorded and uploaded to the website, so students can have the chance to decide when to access to the content.[50]

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[45] http://educacionbasica.sep.gob.mx/

[46] https://www.aprendeencasa.mx/aprende-en-casa/principal.html

[47] https://www.aprendeencasa.mx/aprende-en-casa/archivos/CartaPadres.pdf

[48] Number: 36 01 87 20

[49] tumaestroenlinea@nube.sep.gob.mx.

[50] Consult broadcast programming: https://www.televisioneducativa.gob.mx/

In the establishment of what the government has called the "New Mexican School", the SEP announced that 11 million 111 thousand 458 students have been registered in the program. This includes students from the National Institute for Adult Education (INEA by its acronym in Spanish) and the National Council for Educational Development (CONAFE by its acronym in Spanish).

Aprende en casa results:
11 million students are registered in the program.
All free textbooks are available in a digital version.
420 thousand daily visits to the free textbooks' website.

The free textbooks are considered the backbone of the educational policy and their relevance increases in the distance learning scheme. According to SEP ten out of ten students in the country own them. Besides, as for the digital field, students have responded positively to the National Commission for Free Textbooks' (CONALITEG) website, data show that it registers up to 420,000 visits per day.

Additionally, for those students living in isolated places, CONAFE delivered more than 300,000 packages of school supplies, which represents 99.7% of its target population.[51]

As a complementary element of the "Aprende en casa" strategy, the " Jóvenes en casa" program, which seeks to take advantage of and promote the healthy development of students' socio-emotional skills, reaches both students who have internet and those who don't. It is presented in a booklet -distributed by school staff- and via an online platform - which registers on average 44,000 visits per day-.[52]

This strategy is striving to surpass the traditional schooling system non-available during the pandemic.

Nevertheless, it must address that the primary challenge for this program is the deficiency of telecommunications services access.

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[51] Secretaría de Educación Pública, "Aprende en Casa" thrives with the study of all the children in their Free Textbooks (Mexico, 2020). Available at: https://bit.ly/3g8D5ii

[52] Secretaría de Educación Pública. "Jóvenes en Casa" registers more than 835 thousand visits to its online platform: SEP (México, 2020). Available at: https://bit.ly/2LQT5aU

As explained above, in the case of coverage, the challenge is not in the broadcast tools since it reaches most households. The challenge lies in the access to the online content.

In this sense, the "Aprende en Casa" strategy can take advantage of mobile technologies to reach more users in the educational community. The smartphones and reverse data billing scheme proposed by the Pocket Classroom initiative can be part of the solution.

As explained before, in Mexico there are 111.1 million smartphones, an average of 3 devices per household. This means a penetration of 92% of the population and the reason why the mobile broadband (BAM) could be a suitable complement in the distribution of educational content, but the connectivity gap represents a major challenge. Through a public investment effort, SEP can establish collaboration agreements with the principal carriers in the country to offer reverse data billing schemes.

Summed up to all these tools, the educational program during the quarantine set up the starting point to further distance education programs. As a guiding axis for eLearning, SEP has developed a strong solid platform that certainly set the country up for the application of more innovative tele-educations solutions for the public system in the future.

POCKET CLASSROOM PUBLIC POLICY GUIDELINES

CONCLUSIONS

The Pocket Classroom concept suggests the combination of video gaming, mobile platforms with AI, VR, and AR design characteristics and a reversed data billing scheme. This idea derives from specific evidence shown throughout this document and it is summarized as follows:

1) Video gaming is an important tool for education purposes, it contributes to develop and improve skills such as collective intelligence and creativeness. Also, AI, VR and AR are important tools that make the most of the educational potential of video gaming by making the learning-teaching process more efficient. Therefore, these design characteristics are desirable for a video game.
2) Regarding video game platforms, according with some results of the OECD's Program for International Student Assessments (PISA)[53] 2015, the use of video game consoles at home seem to have a negative correlation with the mathematics, reading, and science OECD countries average score. Nevertheless, the same study for 2009 reveals a positive correlation between the use of mobile phones and a moderate use of one-player games. This suggests that for video games to play a better complementary role in education a mobile platform is necessary.
3) Mobile device has significant adoption patterns in terms of policy inclusion. smartphones penetration is reaching the 100%, and this penetration is practically equal among genders and have a strong presence throughout all socioeconomic levels. It is important to consider that VR, AR and AI technologies require high-capacity devices, suggesting the relevance of high-end smartphones in a Pocket Classroom policy.

[53] PISA data explorer. Available at: https://www.oecd.org/pisa/data/

4) Digital gap suggests the introduction of payment schemes that allow low-income household students to have internet access.
5) The technology-based education policies in Mexico have considered the teaching training side, the delivery of devices, the implementation of ICT-equipped classrooms, and the proliferation of contents. Nevertheless, they have been implemented at an enormous cost, with no relevant impact and lack of continuity and articulation: an innovative policy is needed.
6) The pandemic has opened an opportunity to complement the Government tele-education strategy with mobile technology solutions.

TOWARDS A POCKET CLASSROOM POLICY

The general objective of the Pocket Classroom Policy would be implementing innovative technologies in the education system to improve digital inclusion and skills, and more importantly, to develop XXI century capabilities among Mexican students such as collective intelligence and creativeness.

This policy should focus on students of the Z generation considering they already take advantage of video games and mobile technology. Particularly Pocket Classroom Policy may target 5th and 6th grade students to ensure that all the previous public policy experience is included.

The strategies / enablers to achieve these general objectives are:

1) **Content development.** Generate technical guidelines to develop educational video games (or take advantage of those already available in the market) according with government authorities, pedagogy experts and game developers' perspective.

2) **Content enablers.** Throughout the above-mentioned technical guidelines, the use of AI, AR and VR must be encouraged and emphasized to harness their benefits.

3) **Platform and equipment.** All video games must be cross platform, nevertheless the mobile ones should be prioritized so that social inclusion is ensured. This means that mobile applications software will be required.

4) **Connectivity.** Wi-Fi in public sites (schools or public libraries) and mobile internet access will be needed to download and update mobile applications or content. The connectivity gap can be addressed through reverse data billing schemes.
5) **Teaching training.** Design and implement mechanism to train teachers in the use of video game and mobile technologies so they can improve their own ICT skills and correctly guide, design and practice activities with students.
6) **Activities program.** The collaboration between education experts and government authorities is needed for the design of an activities program for teachers to work with their class. It is important that these activities set a time limit for each activity considering the results from PISA 2009 which shows that the use of one-player games are correlated with better scores only if the use is moderated.
7) **Skills to develop.** A lot of skills can be developed through a videogame-based education policy, nevertheless we would like to emphasize the development of programming skills since they have a loop impact: videogames can be designed to provide or improve coding ability, while coding is a high aggregated value activity that promotes videogame development.

The most important investment on the Pocket Classroom policy seems to be software development and connectivity which constitutes the policy core. It is worth to mention that education software is already available in the market, therefore authorities may only need to collaborate with developers to adapt software instead of creating it.

Only a small fraction of the investment must be allocated to devices delivery since as it was established, most of the Generation Z students already have a smartphone. Therefore, only students without a device or a low-end device should be given access to a high-end smartphone or other device that supports these skills development.

In Mexico there is a two-decade history of ICT-centered education policies. They have been helpful providing citizens with skills required for the XXI century. Nevertheless, the evidence suggests there are more efficient and innovative ways to implement this kind of policies. Education authorities are providing an interesting response to the pandemic emergency by establishing a tele-education program that requires to be strengthened with

a mobile solution. The Pocket Classroom is an evidence-based policy proposal that represents an innovative alternative for the Mexican traditional education system.

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