A Cognitonics Approach to Computer Supported Learning in the Mexican State of Oaxaca

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Cognitonics is a new science which looks at ways to reconcile human socio-spiritual development with increasingly rapid human intellectual development in the new context of technological advances and increased cultural homogeny. This is particularly relevant in areas such as education and informatics where children are found to be increasingly capable to control and adapt to new technological advances yet often suffer from a lack of social development or are unable to engage with aspects of their own cultural heritage. In this study we consider the application of a cognitonics based approach to the problems of the Oaxacan education system, particularly for indigenous children who suffer from a loss of culture and diminished provision of education due to a lack of resources and regular teacher strikes. Specifically, we look at how the introduction of fact-to-face collaborative video games can help develop academic, information-technology and social skills together while promoting spiritual well-being and cultural identity.

1 Introduction

Oaxaca State is located in the south west of Mexico bordering Puebla and Veracruz to the north, Guerrero and Chiapas to the East and West, with the Pacific Ocean to the south. The overall population is around 3.5 million with about a third of the population speaking one of sixteen formally recognised indigenous languages. Around half of these do not speak Spanish and the remaining two-thirds of the population are predominantly mixed or indigenous peoples who have lost their language. The rugged terrain and linguistic or cultural differences mean that people often live in small secluded communities. Many of these communities suffer from limited access to services and employment opportunities. Overall, 53% of the population live in rural areas [1] and 67.2% live in poverty [2]. 60% of the population are under 30 and more than a third of the total population are enrolled in the educational system. Around 700,000 of these are children in primary education [3].

Despite their rich cultural heritage and the resilience of Oaxacan people to general hardship, they are currently faced with a number of serious social and economic challenges. Primary education is particularly problematic with Mixtec municipalities accounting for the majority of the 80% in Oaxaca not adhering to minimum requirements set by the Mexican government [4]. Only 5% of indigenous persons in the state attain a grade beyond primary school level and over 21% of the overall state population is illiterate [4]. These problems can be attributed to a number of factors including low family income [5], disruption of family structures due to high rates of migration [4, 5] and the large percentage of the population that live in remote rural areas [6]. There is also the significant problem that many indigenous teachers have not received formal training [7] and a strong sense that the education system is not properly adapted to best serve the indigenous population.

Most of these social, economic and political problems have their roots in, and are exacerbated by, corruption, which is endemic in Mexico as a whole [8]. Corruption at the fundamental level is the illegitimate use

of public power to benefit private interest. This is when individuals expect illicit payback for services or preferential treatment. While this occurs on different levels with different grades of severity, the result is that people are denied access to opportunities and official structures fail to function in an efficient or just manner. This leads to inequality that leads to frustration, social unrest and criminal activity.

At the root of corruption is a lack of altruistic community spirit [9] or, at a very basic level, a lack of common compassion. A tendency toward corrupt behaviour is not however a natural attribute of the Mexican people but rather a result of the social conditions such as economic hardship and marginalization caused by factors such as the large scale migration of people to urban areas and the subsequent loss of established community structures

Our proposal for working toward a partial solution to this problem is to support the provision of innovative education methods such as collaborative learning. Collaborative learning is where two or more students learn together by working on the same problem. This allows the students to learn through shared experience and face-to-face interaction, in effect capitalising on the inherent social nature of learning [10]. Many of the attributes promoted by collaborative learning are important for promoting community spirit and tackling the root causes of corruption. Important aspects of collaborative learning are positive interdependence, individual accountability, face-to-face promotive interaction, social skills and group processing (or self-analysis of the group) [11]. Our hope is that by developing these abilities at an early age, when young people begin to define themselves as individuals and develop intellectually, we can help avoid the development of the converse negative traits later in life.

Specifically, we look at how collaborative educational videogames can be used to help primary school children develop collaborative and proper social skills while achieving learning objectives that would normally be taught in a traditional classroom environment. This combines the teaching of the classroom syllabus with an introduction to information-technology and the development of essential social skills so as to balance the development of the intellectual and socio-spiritual sides of the student in accordance with the philosophy of cognitonics [12].

2 Related work

Cognitonics aims to help people adapt to and use technology by improving cognitive mechanisms of processing information and developing the emotional sphere of the personality [12-14]. Examples of cognitonics in education are the use of broadband tele-conferencing to allow young people to interface with public figures [15], using technology for the self-evaluation of history lessons [16] and building a mental model of student online activity in an online e-learning environment [17]. Collaborative face-to-face videogames also fall within the scope of congnitonics since they aim to promote a more sociable and culturally relevant learning experience [18-20]. While the concept of using collaborative videogames for cognitonics is a relatively new development, there is a long history of technology being used in Mexican education and in many regards collaborative games can be seen as a logical progression from these technologies.

2.1 Distance learning

Over the years various Mexican governments have recognized the problems of delivering education in remote and marginalized areas and sought to remedy these problems through the application of technology [21]. The most successful programs have been in the area of distance learning [22] supported by television networks and courses delivered through the mail. Computer based learning has been somewhat less successful due to problems of IT infrastructure and the cost of equipment.

In the late nineties Ernesto Zedillo introduced a program of Distance Education aimed at bringing quality education to remote areas without the necessity for students to relocate or travel large distances to attend classes. Since then, three distinct projects have been put into place to provide Distance Learning in Mexico. These are the Educational Satellite Television Network (EDUSAT) [23] which provides support for the training and development of teachers, the Red Escolar (Scholar Network) [24] which provides education in information technologies and Telesecundaria (Tele-secondary school) [25] providing general and technical secondary education.

The provision of computer based distance learning material is limited in Mexico and its usefulness is questionable as very few Mexicans stand to benefit from this type of education in its traditional form. Traditionally, computer based distance learning means learning at home and few Mexicans have a suitable computer at home. According to the INEG, as of 2006, only 58.7% of the population have access to a personal computer with only 45% having access to the internet [26]. These figures are likely to be a lot worse for less advantaged sections of the population who stand to benefit the most from distance learning programmes.

2.2 Computer based distance learning

Enciclomedia [27] is the Mexican governments most committed effort in the area of computer based distance learning to date. This was released in the 1990s, incorporating videos, text, virtual visits, sounds and images to complement free textbooks. Later versions of the service incorporated content from Encarta [28] provided by Microsoft and integrated resources, activities and audiovisuals generated by projects such as the Red Escolar [24], Biblioteca Digital, Sec 21 and Sepiensa [29]. However, the project was not generally considered a success. Teachers found the material to be inconsistent and, according to primary teachers in the nation capital, the program ceased to be used altogether from the 2010 when as part of the Basic Education Reform the content

free textbook was changed without the program being updated [30].

Other private initiatives tended to concentrate on the provision of computer equipment in the classroom. In 2009, Mexican billionaire Carlos Slim donated 50,000 laptops for use in Mexican schools from the One Laptop per Child (OLPC) program [31]. Kids on Computers [32] is another important program, working in Oaxaca to recycle used computers for use in rural schools. A general criticism of these types of program is that they can do little to serve the immediate needs of the population such as the supply of food and availability of clean water [33]. This isn't so much of an issue however in nations such as Mexico where the problems of development are more to do with organization and infrastructure rather than resources. In the Mexican context these programs certainly have a great potential to improve conditions for the general population.

2.3 Collaborative learning games

The use of collaborative games is a form of learning that has already shown promise to improve the education of children while at the same time helping to develop positive character traits. This is reflected in the vast majority of research on the subject which indicates that students learn more effectively when they work collaboratively [34]. Several studies point out benefits of using collaborative methods in education [35]. These include that;

- Students learn more.
- Students are more positive about school, subject areas, and teachers or professors.
- Students are more positive about each other regardless of differences in ability, ethnic background, or physical disability.
- Students are more effective interpersonally as a result of working cooperatively: Students with cooperative experiences are more able to take the perspective of others, are more positive about taking part in controversy, have better developed interaction skills, and have a more positive expectation about working with others.

These results aren't surprising since we already know that students tend to learn more in social situations [10] and collaborative learning is intrinsically social. Moreover, there is strong evidence that indigenous Mesoamerican peoples in particular have a cultural disposition to collaborative learning rather than the traditional directed approach [36] and children from this background may not adapt well to the more authoritarian European-American classroom model [37]. These are all reasons to assume that collaborative learning games might form part of a successful strategy to improve primary education in Oaxaca.

3 Collaborative face-to-face videogames in the state of Oaxaca

Over-and-above the aforementioned pedagogical benefits of collaborative learning, there are a number of practical reasons why collaborative videogames could form part of a realistic solution to the problems of the Oaxacan education system. Videogames do not depend on supervision or on language, they are also relatively cheap to implement and maintain, and suit the way that children naturally learn. Collaborative games can also help children learn how to work together. This ability to work together is in itself an important life-skill that's often neglected in the traditional model of classroom education where children strive toward individual merit over the good of the group. By encouraging students to develop team working skills at an early age we feel this should better equip them to grow into adults who are more able to work together towards resolving some of the more entrenched problems of Oaxaca and Mexican society.

Developing these skills at the same time as they learn to use new technologies should also allow the students to develop a more wholesome relationship with technology and suffer less from adverse effects such as isolation and retarded social skills [13, 38].

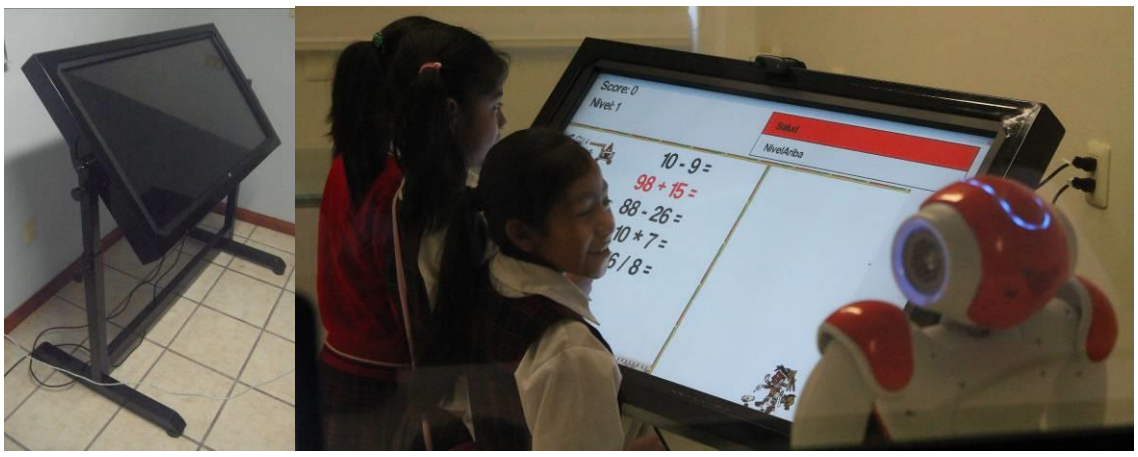

Figure 1. Setup of the games. Left, custom games stand set at 45 degrees and, right, children playing the games with a robot assistant.

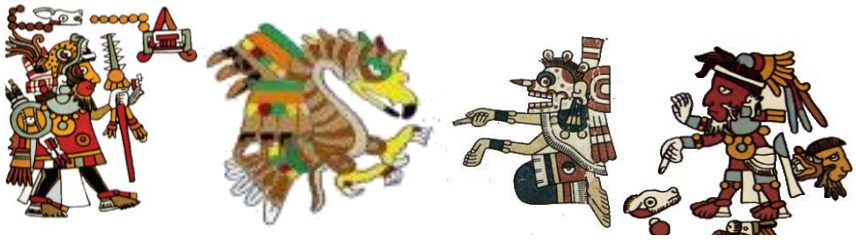

Figure 2: Mixtec codices used as characters in the mathematics and languages videogames: Jaguar, eagle, muerte and mixteco.

3.1 Methodology

Our experiments to investigate how collaborative videogames might be used in Oaxaca involved six groups of three children aged eight to ten years. Each group spent two hours in total playing three educational videogames. Games were played on a forty-two inch multi-touch screen angled at forty-five degrees and raised between waist and head height to be ergonomically accessible (see figure 1). The children were observed through two-way glass with audio and video recorded throughout the sessions to give us a permanent record of results. The groups consisted of four groups all female and two groups all male.

Each child was tested immediately before, immediately after and four days after their session. The exams used for testing included three five minute sessions testing mathematics, languages and reading. The students were also asked to fill in questionnaires to provide us with more subjective information relating to how they felt about the games and working as a team. In addition to this, observations made during the tests allowed us to assess the dynamics of the groups telling us how the students interacted and how collaboration strategies evolved.

3.2 Videogame design

The three educational games developed for our experiment supported the learning of mathematics, languages and reading. In order for the games to be both accessible and challenging for children with different levels of learning, we incorporated a gradually increasing level of difficulty for each game. Other key aspects of game design were promotion of inter-student interaction, cultural relevance and age appropriateness. Here we tried to ensure that the games were non-violent and did not enforce gender stereotypes while encouraging the children to identify with elements of their native Mixtec and Mexican culture.

Two of the three educational videogames developed for the project (those designed for mathematics and language learning) make use of graphics based on Mixtec codices (see figure 2). Codices are a form of colourful hieroglyphic used by the early Mixtecos to record their history. While these are no longer used today for writing, they remain a strong symbol of Mixtec culture used in logos, books and t-shirt designs. Parts of the costumes seen in the codices are also used in traditional ceremonies and festivals. The codices used in the games are; the jaguar, the eagle, the muerte and the Mixtec man. Muerte can be literally translated as death and the character used in our game represents a dead friend or relative returning to visit the living. To western eyes this might seem a morbid character to include in a video game for young children but the Mixtecos have a somewhat different attitude to the symbolism surrounding death. Mixtecos consider the ‘day of the

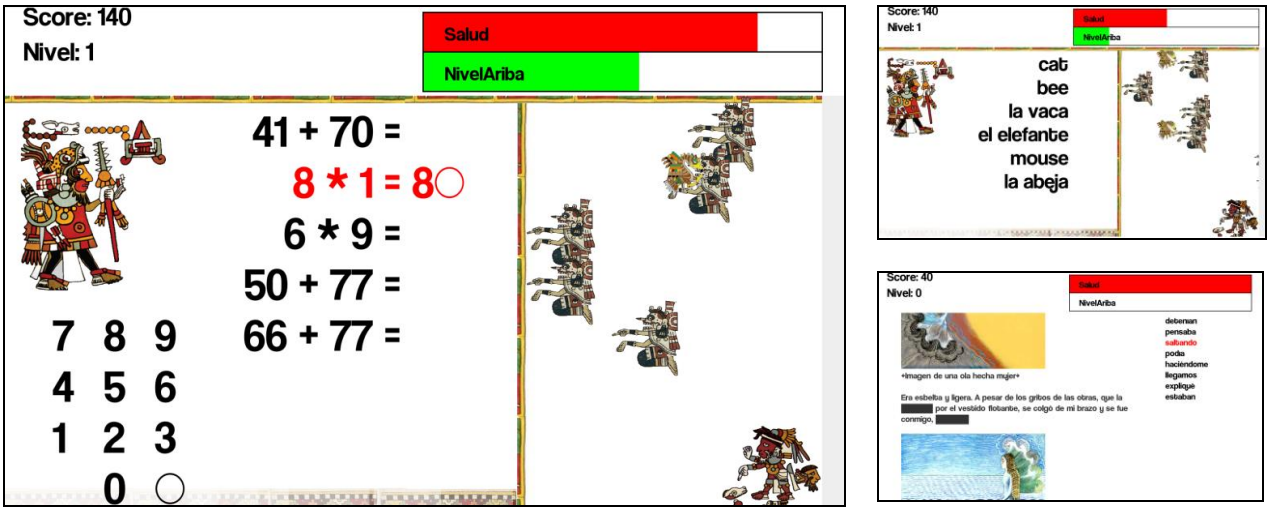

Figure 3. Screenshots of the educational videogames; left mathematics, top right languages and bottom right reading.

dead', when the dead are said to return to visit their loved ones, as a happy occasion to be celebrated with bright colours and loud music.

The mathematics game developed for the project (figure 3 left) is a simple 'tower defence' type game where the students have to solve mathematical equations to fire eagles and prevent the muertes from reaching the perimeter wall of their 'tower' and draining their energy. The character of the user, the jaguar, sits at the left hand side of the screen. Below this character is a keypad and to the right a list of sums. To the right of the sums is a vertical wall and beyond the wall are the muertes. Each muerte advances slowly from right to left toward a sum and if a muerte reaches the wall it stops and begins to drain the health of the user. When the health of the user reaches zero the game is over. In order to stop muertes reaching the wall the user can answer sums to fire eagles. The user can press on different sums to answer them using the keypad. If a sum is answered incorrectly health is drained and if a sum is answered correctly an eagle is fired from the wall toward the right hand side of the screen. When a muerte is hit by an eagle it is pushed back away from the wall. Pushing back muertes also adds to the users score and causes the level-up bar to rise. When the level up bar is full, every sum fires an eagle to push all the muertes back and the user progresses to the next level. As the level increases, the muertes begin to speed up and it becomes gradually more difficult to do all the sums on time to keep the muertes away from the wall.

The languages game help students to learn the names of animals in English (figure 3 top right). This game is another 'tower defense' type game similar to that used to learn mathematics described above. However, instead of doing sums to fire eagles the students have to match words in English to their Spanish translations. When words are matched correctly eagles are fired from both words and health is drained when words are matched incorrectly. The game begins with a small number of words for more common animals such as cats and dogs. As the game advances the difficulty level increases with a wider variety of gradually more obscure animal names. If the children are not already familiar with the names of these animals in English, they can normally find the translations out by trial and error and learn from their mistakes.

The reading game (figure 3 bottom right) aims to help the children with reading by asking them to complete a story by replacing missing verbs. Literature and authors are held in particular esteem in Mexico, and Latin America in general, with popular authors often considered as national heroes. This game encourages the children to explore the Mexican national side of their identity by using an adaptation of the short story 'Mi vida con la ola' by Mexican Nobel laureate for literature Octavio Paz.

3.3 Results

Our experiments provided us with three types of results. Firstly, short exams taken by the students immediately before, immediately after and four days after the experiments allowed us to assess how the games contributed towards specific short-term learning objectives. In addition to these exams, the students were asked to fill in questionnaires to provide us with more subjective information relating to how the students felt about working as a team throughout the sessions. Finally, observations made during the tests allowed us to observe the dynamics of the groups and how strategies evolved during the sessions.

3.4 Exams

Table 1 summarizes the improvement in the children's performance in the exams after the session with the educational games. Here we can see that the children's performance did not improve significantly, or deteriorated, immediately after their session with the games. This was most likely due to the children being tired and over-stimulated after playing the games for two hours. When the students were tested again, four days after the tests, there was a significant improvement in their performance. This improvement was particularly marked for mathematics where the student's performance showed an increase of 21.9%. The improvement for languages was 4.3% and the students regressed slightly in their reading (by 2.1%). In order to statistically validate our results and account for inter-sample variance we performed a single-tailed t-test. This gave a p-value of 0.016 for the second test to indicate that it was highly likely the children's improvement was due to their exposure to the games rather than variation of the children's scores overall. The p-value for improvement

		Improvement in performance							
		Immediately after the test				**four days after the test**			
		Maths	**Languages**	**Reading**	**All**	**Maths**	**Languages**	**Reading**	**All**
girls	**%**	**10.00%**	**0.96%**	**0.00%**	**3.65%**	**22.08%**	**2.56%**	**1.04%**	**8.56%**
	p-value	0.111	0.421	0.500	0.243	0.012	0.215	0.500	0.393
boys	**%**	**9.17%**	**-0.64%**	**-25.00%**	**-5.49%**	**21.67%**	**7.69%**	**-8.33%**	**7.01%**
	p-value	0.065	0.468	0.005	0.130	0.012	0.089	0.282	0.016
all children	**%**	**9.7%**	**0.4%**	**-8.3%**	**0.6%**	**21.9%**	**4.3%**	**-2.1%**	**8.0%**
	p-value	0.067	0.458	0.148	0.439	0.002	0.198	0.387	0.031

Table 1. Improvement in child performance assessed by exams administered after a session with collaborative educational games.

in the mathematics test was 0.0018 indicating a greater probability that the children's improvement was due to their exposure to the games. The p-value for the language test was marginal at 0.20 (0.089 for the boys) indicating that there is insufficient evidence to conclude that exposure to the games caused an improvement in the children's results (using the standard p-value threshold of 0.05). Results also indicate that there is insufficient evidence to conclude that the *drop* in reading performance was due to exposure to the reading game (with a p-value of 0.38).

3.5 Questionnaires and observations

The questionnaires filled in by students and observations made during the experiments provided us with more subjective information regarding the benefits of our educational games. The first thing we noticed was the short time the children took to learn how to play the games. On average it took around two minutes for the children to develop an understanding of how each game worked. During the following five or ten minutes the children would develop basic game strategies and continue developing these while playing the games. The students also developed collaboration strategies such as coordinated turn taking, task delegation and thinking aloud. In general, the boys tended to prefer the mathematics game while the girls preferred the reading game. The boys and girls also tended to use different strategies for the reading game. The girls would read larger sections of the text aloud, following the story. Boys tended to use a more direct strategy of reading individual sentences and trying to use grammatical rules to choose a word. The boys also tended to be more competitive, celebrate more when an answer was correct, and argue more over whose turn it would be to operate the interface. All of the student groups spent around about equal time playing each of the different games and tended to spend around twenty minutes or half an hour playing a game before moving on to the next.

The positive feelings the children had toward the games were reflected both in observed behaviour and questionnaire results. At the end of the sessions the children wanted to continue playing even after two hours. In the questionnaires the children told us they enjoyed the gaming sessions and would be very happy to use the games for future learning. The children particularly enjoyed being able to learn together with their fellow students and found the graphical nature of the games stimulating. They recognized the characters from the codices and felt this helped them relate to the games. The story used in the reading game was not familiar to the students but those who followed the text in the session expressed an interest in learning more about the story.

4 Conclusion

The results of the evaluation presented in this paper demonstrate the potential of collaborative games to improve the educational experience of children in the Mixtec region of Mexico. This includes the development of academic abilities and inter-personal skills together so as to realise a more balanced learning experience and prevent more negative personality traits such as isolation and anti-social tendencies that might otherwise be the result of less interactive education models such as private study with a computer [13, 14].

Evaluating exam scores before and after gaming sessions showed a statistically significant improvement of over 20% in results for mathematics. Results for the languages were positive though not conclusive due to the small sample size and natural variation between student grades. While the exam results did not show an improvement for reading, a number of children involved in the study felt encouraged to develop an interest in the story presented during the game.

More importantly, the games allowed the children to develop important team working skills and encouraged them to identify with different aspects of their native culture. While it is normal for students to interact during playtime, interaction during class-time is relatively scarce and since team working is such an important skill in the modern work-place we feel that this would make our collaborative videogames a valuable addition to the children's schooling.

It is also important that the games worked well with children working together while using information technology. We believe that this type of working can move children away from the idea of computing as a solitary anti-social activity and towards a more positive outlook where computers are seen as a tool for helping rather that replacing human interaction. The exercise also prepares the students for new computing paradigms such as ubiquitous computing and augmented reality that are likely to involve concurrent collaborative working in the future.

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