How Dr Math reaches Pupils with Competitions and Computer Games by using MXit

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Abstract: In a world where school books, pencils and paper have to compete with cell phones, IPODs, and MP3 players for pupils' attention, Dr Math entices pupils to practice basic mathematics skills by providing games and competitions using Mxit over cell phones. Dr Math is a Mxit contact which pupils can add which gives pupils the opportunity to compete with other pupils in basic arithmetic skills such as addition and multiplication and more advanced mathematics skills such as factoring a polynomial and finding the prime factors of a number. In addition, interactive fiction games are available with mathematical twists in a plot that require some basic arithmetic skills to solve the puzzle. And, all of this is done over Mxit – South Africa's leading instant messaging provider – on cell phones.

Keywords: cell phone, Mxit, interactive fiction, Inform, mathematics

1. The Current High School Generation

The high school pupils of the "Class of 2009" (those teenagers who are turning age 18 in 2009, are currently in Grade 12, and leaving school this year) have never lived without the Internet. In 1990 (one year before the "Class of 2009" was born), TCP/IP had supplanted or marginalised most proprietary computer network protocols worldwide [1], Microsoft released Windows 3.0, and Creative Labs produced the Sound Blaster. This was not just a first-world phenomenon. The Internet, Windows 3.0, and Sound Blasters migrated to Africa before the "Class of 2009" was born.

But mathematics education often struggles to keep up with these technological innovations. Mathematics education in Africa (and specifically, in South Africa) could use some innovative ideas [2] to help improve the quality of mathematics education.

The question we asked ourselves was whether or not we could present basic arithmetic skills training in a mode or medium that would be attractive to the "Class of 2009." Could technology such as instant messaging, cell phones, Mxit, and interactive fiction be combined to make practicing multiplication tables exciting and fun for the "Class of 2009"? Could the "Class of 2009" be enticed to practice integer division if it was presented as part of a game deployed over cell phones?

This paper describes a project where pupils could take part in competitions in basic arithmetic skills such as addition and division using Mxit on their cell phones. In addition, pupils could also play interactive fiction (text adventure games) with a mathematical twist in the plot using Mxit on their cell phones.

2. Mxit - background

Mxit is a cell phone application that runs on most modern cell phones [3]. It is proprietary software of Mxit Lifestyle (Pty) Ltd. Mxit Lifestyle (Pty) Ltd is a South African company based in Stellenbosch, South Africa. The software is free of charge and provides instant messaging facilities over cell phones at a fraction of the cost of normal SMS messages. The low cost of using Mxit is one of the reasons that Mxit is popular with teenagers.

Mxit press releases state that Mxit has over 8.6 million registered users and is processing more than 250 million messages per day [4]. Articles in the popular press quote the Mxit Managing Director, Herman Heunis, as saying that Mxit has more than nine million logins per day and ten thousand new subscriptions per day.

Those are impressive statistics – especially if you are attempting to reach the under-25s. According to Mxit's website, the Mxit community is predominately between 12 and 25 years old.

3. Dr Math – a brief history

Dr Math started in January 2007 [6] as a tutoring system. Primary and secondary pupils who had Mxit installed on their cell phones already could access a tutor from the University of Pretoria to assist them with their mathematics homework. The tutors would be using full sized computer work stations connected to the Internet. Pupils would be using Mxit on their cell phones spread around the country. The Dr Math facility grew by word-of-mouth viral advertising. As of the writing of this paper, more than 4500 pupils have used the Dr Math facility.

During the course of tutoring, however, our Dr Math tutors commented that the pupils continued to make stupid mistakes. Often upper grade pupils (such as grades 10 through 12) would stumble on simple addition or multiplication calculations. Plus lower grade pupils (such as grades 3 through 6) continually asked our tutors to test them on simple calculations.

4. Competitions

During the Christmas school holiday break December 2007, the first of Dr Math's arithmetic competitions was deployed. This first competition was a small prototype where pupils could compete at adding two integers together. The range of the calculations went from 1+1 up to 12+12. The rules of the competition were simple:

- When a pupil entered a competition, he or she would be given the alias of the current TopScore of the competition and the percentage correct which the current TopScore optained
- The pupils would be given 10 calculations ranging from 1+1 up to 12+12
- If the pupil tied or bettered the existing TopScore, then this new pupil would become the TopScore
- As a pupil remained the TopScore, the upper limit of the calculations got higher and higher
- The old TopScore would be sent a message that he or she was deposed as TopScore and was invited to come and defend the title

The last point, the message sent to the deposed TopScore, was the key to getting the pupils to compete among themselves. Our log files show that participants regularly returned to defend their title as the TopScore. Participants regularly did dozens of calculations and, often, they did hundreds of calculations.

Over the course of the next few months, we eventually implemented 9 competitions including:

- additional
- subtraction
- multiplication
- division
- prime factors of a number
- root of a straight line
- intersection of two straight lines
- factors of a quadratic
- real roots of a quadratic

From reviewing our log files, we found that many competitors would do hundreds of calculations in order to remain the TopScore often competing until the early hours of the morning and then checking their rankings the first thing when they awoke.

5. Ethics and Safety

From the onset of the Dr Math project, the safety and security of the minor participants was of paramount importance. The print press and the online press regularly carry articles about social ills where Mxit had been used merely as a medium of communication. Alleged kidnappings of teenagers has been blamed on Mxit [7]. Defamatory statements have allegedly been published in Mxit chat rooms [8]. In 2007, Patricia de Lille, the president of the South African political party Independent Democrats, called on the South African government to regulate Mxit [9] (along with internet blogging).

With this in mind, Dr Math took the following steps to ensure the safety of the participants:
- Ethics clearance was obtained from the ethics committee of the Tshwane University of Technology
- Tutors must sign a code of conduct agreeing not to physically contact any participants
- All conversations are recorded and monitored
- Participants are regularly told not to give any personal details out over Mxit

6. Mathematics as a tool for Social Upliftment

From the detailed log files which are kept by the Dr Math project, we find that often mathematics can be used a tool for social upliftment. The following extract from our log shows an interesting phenomenon. A participant with the alias Pimp Star starts competing in Dr Math's polynomial factoring competition.

2008-04-08 17:28:12,854 PIMP(*)STAR:

2008-04-08 17:28:12,917 Bot -> PIMP(*)STAR: The current TopScore is einstein's mother with 100%. To clear your score and start over send .z with nothing after it. TopScores are updated after 10 questions. What are the FACTORS of the polynomial $x^2 +10x +24$ Write the factors in the form .z x+3 x-7 with one space between the factors.

2008-04-08 17:28:53,099 PIMP(*)STAR: x+4 x+6

2008-04-08 17:28:53,108 Bot -> PIMP(*)STAR: Correct. Your score is 1 correct out of 1 or 100%. The current TopScore is einstein's mother with 100%. What are the FACTORS of the polynomial $x^2 +8x -9$ Write the factors in the form .z x+3 x-7 with one space between the factors.

2008-04-08 17:29:33,177 PIMP(*)STAR: x+1 x-9

2008-04-08 17:29:33,269 Bot -> PIMP(*)STAR: Wrong. The factors are x-1 and x+9. Your score is 1 correct out of 2 or 50%. The current TopScore is einstein's mother with 100%. What are the FACTORS of the polynomial $x^2 +13x +36$ Write the factors in the form .z x+3 x-7 with one space between the factors.

The participant does reasonably well and, eventually after a few hours, becomes the new TopScore:

2008-04-08 22:51:23,498 Bot -> PIMP(*)STAR: Correct. Your score is 10 correct out of 10 or 100%. Congratulations. You are the new TopScore. What are the FACTORS of the polynomial x^2 -7x -44 Write the factors in the form .z x+3 x-7 with one space between the factors.

We allow participants to change their aliases. The alias Pimp Star is not a particularly flattering alias. But, after winning the competition, this participant tries out a few other aliases such as Qun of Maths (probably meaning Queen of Maths):

2008-04-08 22:52:43,546 Bot -> PIMP(*)STAR: We currently know you as PIMP(*)STAR. Send us a .n followed by the new name you want on our system.

2008-04-08 22:54:23,600 PIMP(*)STAR: Qun of maths

2008-04-08 22:54:23,613 Bot -> Qun of maths: We have changed your name to Qun of maths on our system.

And eventually settles on the alias smartyCAT:

2008-04-08 22:55:23,649 Bot -> Qun of maths: We currently know you as Qun of maths. Send us a .n followed by the new name you want on our system.

2008-04-08 22:56:03,676 Qun of maths: smartyCAT

2008-04-08 22:56:03,684 Bot -> smartyCAT: We have changed your name to smartyCAT on our system.

It is an interesting example of success in mathematics making positive contributions to social problems.
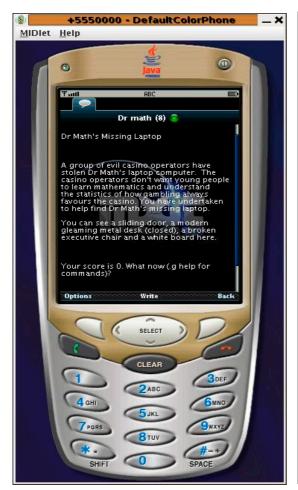

7. Interactive Fiction

In general, the competitions are extremely popular with participants playing numerous times per day. However, a couple of competitions are not popular – division being one of them. Dr Math needed a mechanism to really entice participants to practice division calculations.

The term *Interactive Fiction* refers to works of fiction where the reader can change the flow of the story or change the plot of the story by certain inputs. Many examples of interactive fiction are completely textual with no images or graphics at all. These works of fiction are also often called *Text Adventure Games*. Text adventure games are one of the oldest forms of computer games [10].

Text adventure games give the player or reader a maze of some sort. The virtual maze could be something like a cave, a building with many rooms, or a city with streets. The player or reader could navigate through the game with simple text commands such as "go west" or "enter door." Along the way, the player or reader could pick up useful items with commands such as "take key" or "take matches." Objects could be manipulated with commands such as "throw ax" or "unlock door."

Mxit is an ideal medium for text adventure games because of the textual nature of Mxit. We wrote a text based adventure game with a mathematical twist in the plot. In the text adventure game, all of the doors were secured with digital locks or digital keypads. The players or readers would find the formulae for the locks written on white boards, black boards, or in the dust on old desks. In some cases, the formulae would be sent as an SMS or text message to the virtual player in the game (not to the actual player's cell phone). The formulae were division calculations and the resulting quotient would be the key to the lock.

We used Inform [11] game compiler as a development environment for the adventure game. It is freely downloadable and is available for Windows, Mac, Linux and Solaris. Inform allows the interactive fiction author to write a story with multiple threads (or skeins), conditional expressions allowing the plot to take twists and turns, random number generation (so that each time the adventure is played, the plot is slightly different), along with such housekeeping facilities such as save and restore. In addition, Inform allowed the author to create new actions applicable to a certain class of objects. In our case, we created a new action so that participants could enter commands such as "key safe to 12" or "key cell phone to 8" in order to open doors or access the virtual cell phone.

Inform compiles the adventure which the author created and generates a *Z-code* file. This file needs to be interpreted at play-time. Although Inform can be used to interpret a *Z-code* game file, we used *jzip* to interpret the adventure game at play-time because it was a smaller application without all the graphical overheads of full development system.

The developers of the Dr Math tutoring platform had no gaming experience before attempting to write their first adventure game. Although the following comments may be well known in game-authoring environments, they were new to the Dr Math developers:

- Numerical scores of some sort must be kept. Players needed a goal to attain. Before we implemented numerical scores, participants would play for a while and then go away. Once we implemented numerical scores, participants played for longer periods of time.
- Competition was important. Players needed to be inspired to attain higher scores by comparing their scores with other participants' scores. We eventually used the same

philosophy as our arithmetic competitions and told participants who was the current TopScore. And if the TopScore was changed, the old TopScore was informed of this and invited to come back to defend his or her title.

- Players needed short term goals and long term goals. It was just not good enough to have an end goal (in our case, to find Dr Math's missing laptop computer). There needed to be intermediary goals such as getting out of a locked room, getting the cell phone to work properly, recharging the LED torch, etc.
- Because it could take substantially longer periods of time to play this game than with our other arithmetic competitions, we allowed players to save and restore their game state.

Our log file data shows that many participants played for nearly an hour doing numerous division calculations in order to solve the puzzle set out in the adventure game.

8. Human Resources Issues

The Dr Math platform has evolved over the period of its existence. The core client/server platform which communicates with Mxit, manages tutors, manages competitions and games, manages pupil contacts was developed in approximately one man-month. The platform is written in Java. Individual competitions can easily be written and deployed on the platform within a day. Adventure games take longer to develop because there is the game development component along with minor Java development.

Finding good tutors is the key behind the entire success of Dr Math. The pupils use Dr Math primarily for help from a human tutor. The games and competitions are additional features, which keep the pupils busy when there are no human tutors.

We currently have had 4500 pupils use the Dr Math service over the past two and half years. Because of our ethical clearances, we do not keep any personal details about the pupils. Some of those 4500 are now idle and we assume that they have graduated from high school.

However, when human tutors are online in the afternoons after school, they will often chat with approximately *100 pupils per hour*. This means that the tutors must be able to type quickly and have a really good understanding of the high school mathematics. Our tutors often work in pairs where one tutor is typing and chatting with the pupils and another tutor is scratching his or her head figuring out some mathematics.

9. Conclusions

Text adventure games or interactive fiction with a mathematical twist can be used successfully to entice teenagers to practice mathematical skills – especially if the game is deployed using a medium that teenagers love – their cell phones. The random number generator which is available in the *Z-code* format allows the game author to change mathematical formulae in the games. This can also be used to change the flow of the game.

Although we are happy with the popularity of our adventure games deployed under Mxit, we found that although the Dr Math developers were professional *computer* programmers and could easily write code for a game, the *computer* programmers were not *game* developers and did not understand the philosophy behind games development.

10. The way forward

There are a number of things we would like to try in the future:

1. Although computer programmers can learn to program games, they do not necessarily understand the philosophy of games development. We would like to have a professional games developer assist us on a game.

2. Although games can be used successfully in a learning environment, recent research shows that encouraging pupils to actually *write* their own games is even a better learning environment [12]. This is especially true of teenagers who have grown up playing computer games [13]. We would like to create and maintain a website where pupils could write mathematical oriented text adventure games and our website would deploy the games so they could be played using Mxit as a medium.
3. The whole idea of a combination of text games and Mxit could be used as an educational tool in many disciplines. Games could be written which provide information about HIV/AIDS, malaria, or tuberculosis. Deploying these games so that they could be played over cell phones could be a inexpensive way of educating the public (especially vulnerable teenagers) about these diseases.

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