MOBILE
COMPUTING
LAB

RESEARCH REPORT

Teaching computational thinking with iPads in Thai primary schools: The Foos case study

Friday 18th March 2016

Executive Summary

The results of an experiment with 6-10 year olds in a primary school in Thailand showed that using The Foos in the classroom for 1 hour per week for a 3 week period contributed to a significant improvement in the children's computational thinking skills:

- 23% improvement in sequencing tasks
- 19% improvement in one dimensional navigation tasks
- 18% improvement in two dimensional navigation tasks

Particular groups of students benefitted considerably by using The Foos for 3 hours:

- 6 year old students improved on average by 40%
- Low ability students improved on average by 46%
- 7 year old students performed only 4% lower than 9 year old students
- 31% of 6-7 year olds were able to perform as well as the average 9-10 year olds
- Female students outperformed male students before and after playing The Foos

About Mobile Computing Lab

Based in the Department of Computer Science & Information Technology at Naresuan University, the Mobile Computing Lab is a research group specialising in the application of smartphones and tablets in areas of local and national development such as education, health and tourism. The case study described in this report is part of a project jointly funded by the Thailand Research Fund and Naresuan University to analyse opportunities for using tablets in primary schools to boost learning. For further information please visit the website at www.mobcomlab.com.

Method

Participants

The participants of the study were primary school students from Wat Dhammakaset School, a school in the province of Phitsanulok in the lower north of Thailand. The students typically come from nearby villages around Ban Klang within the Muang district.

The Thai primary school system (*Prathom*) consists of 6 years (P1 - P6), with students starting at the age of 6. The participants in this study were 69 students from years P1, P2, P4 and P5 with typical ages between 6 and 10 years old as highlighted.

Table 1. Participants by Prathom level

Level	Typical age	No. of students
P1	6 years old	10
P2	7 years old	16
P3	8 years old	-
P4	9 years old	20
P5	10 years old	23
P6	11 years old	-
	Total:	69

Most of the students have previous exposure to technology, due to previous work undertaken with iPads in this school. The students had little or no exposure to programming or computational thinking in the classroom before the experiment.

Procedure

The participants engaged in three 1 hour activities using The Foos over a three week period.

A pre test was undertaken immediately before the start of the activities and a post test was undertaken one week after the end of the activities. The test consisted of 12 questions (described below) that tested students computational thinking in three areas: sequencing , one dimensional navigation, and two dimensional navigation. The difference in pre and post test scores was used to measure each student's improvement in their computational thinking skills.

As part of the pre and post test, the students were also asked to answer a short survey consisting of questions:

- to determine their background (age, interests) including how often they use technology at home (e.g. *how often do you use a tablet at home?*)
- to give their interest in a career in technology (*would you like to work in IT?*)
- to evaluate their own ability in computing, maths and art through comparison (e.g. *are you better at maths or art?*)

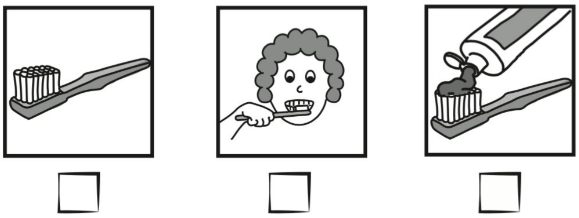
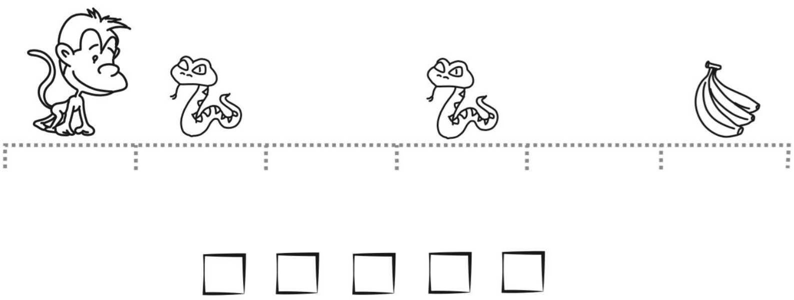
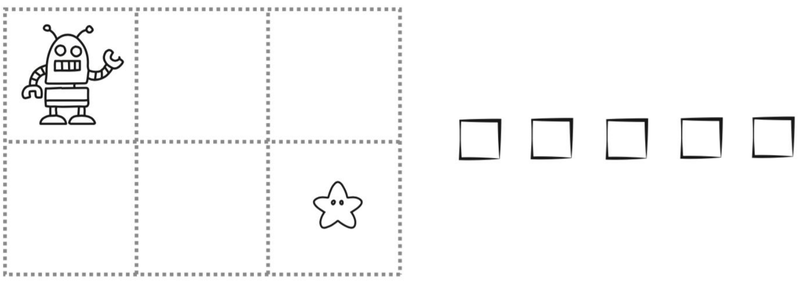
Pre and post test

The questions on the test consisted of:

- 5 sequencing questions (e.g. brush your teeth, put the steps in order), including 2 flexible sequencing questions that had more than one correct answer.
- 4 one dimensional navigation questions (e.g. walk/jump the monkey to the goal avoiding the snakes).
- 3 two dimensional navigation questions (e.g. move up/down/left/right to navigate the robot to the goal).

The pre and post test questions were the same. Examples of each type of question are shown in Table 2.

Table 2. Example questions from pre and post test

	Sequencing question
	One dimensional navigation question
	Two dimensional navigation question

Results

The results are divided into three sections: the pre and post test scores, analyse of the improvement between pre and post test scores, and the survey results.

Pre and post test scores

In the pre test the scores followed a linear pattern with year of study, as shown in Figure 1. The youngest students in the experiment (P1) achieved only 38% on the pre test, whereas the oldest students (P5) already averaged 83% on the pre test. By the post test, all years of students were achieving much closer scores within the range 80% to 90%.

When considering gender, the results of the pre test showed that girls were considerably better computational thinkers than boys, before being exposed to any classroom time on computational thinking. The female students outperformed the male students in all three categories (sequence, navigation 1D and navigation 2D). In the post test, both female and male students made significant improvements resulting in much closer overall post test scores. In fact, the female students outperformed the male students in both pre and post tests, as illustrated in Figure 2.

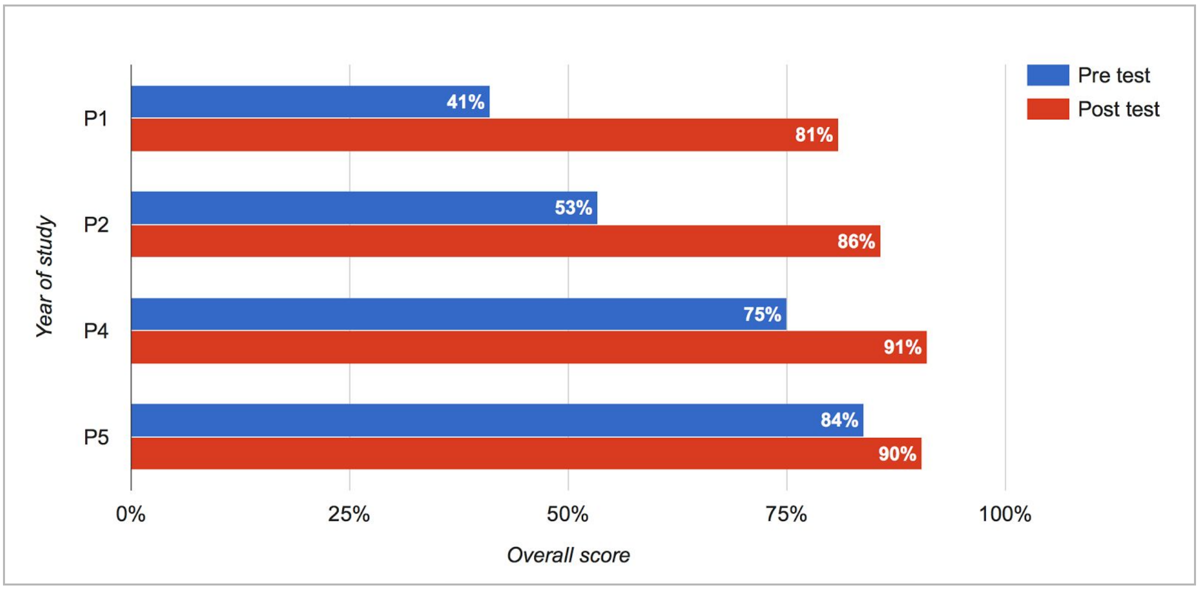


Figure 1. Pre test vs post test scores by year of study

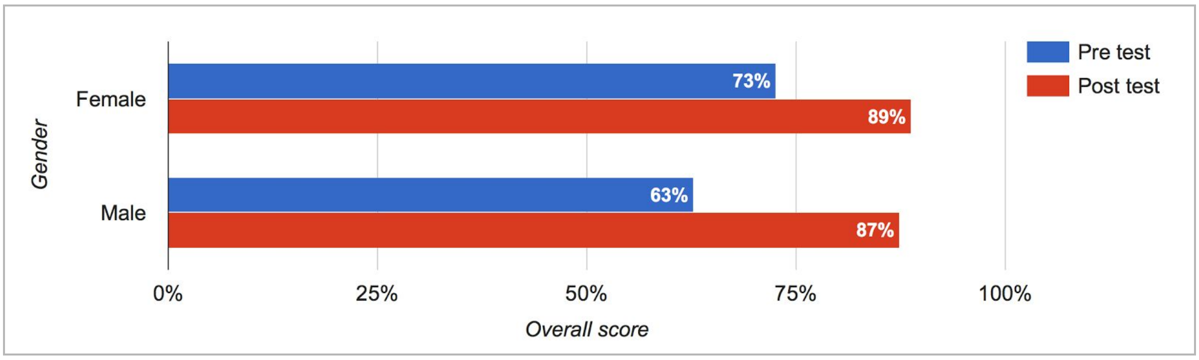


Figure 2. Pre test vs post test scores by gender

Table 3. Pre and post test scores overall and by year and gender

		No. of students	Pre test				Post test			
			Seq	Nav 1D	Nav 2D	**Overall**	Seq	Nav 1D	Nav 2D	**Overall**
All		69	66%	65%	74%	**68%**	88%	84%	92%	**88%**
Year of study	**P1**	10	56%	38%	29%	**41%**	86%	77%	80%	**81%**
	P2	16	53%	46%	61%	**53%**	76%	84%	97%	**86%**
	P4	20	61%	76%	88%	**75%**	92%	87%	94%	**91%**
	P5	23	83%	79%	90%	**84%**	94%	85%	93%	**90%**
Gender	**Female**	37	71%	68%	78%	**73%**	90%	84%	92%	**89%**
	Male	32	59%	60%	69%	**63%**	86%	84%	93%	**87%**

Key observations from Table 3:

- Pre tests by year of study showed that P4 and P5 were already averaging over 75%, and in the post test these students were averaging over 90%.
- Pre tests by year of study highlighted a big gap between P1 and P5 (38% to 83%), but after using The Foos the post test showed that the gap in achievement narrowed considerably to 81% to 91%.
- P2 students performed only less than 4% lower than P5 students in the post test.
- Female students outperformed male students in pre and post tests.
- Female students had significantly higher pre test scores in all areas of computational thinking that were tested.
- Male students made a significant improvement in their scores after using The Foos.

Statistical significance

Table 4 considers the significance of the pre and post test scores by applying a paired samples t-test. The relevant values are highlighted in **bold**. The low value for p (< 0.001) concludes that there is a very small probability that the score improvement occurred by chance. Hence there is strong evidence that The Foos activity improves computational thinking scores in the categories tested. It improves the scores on average by 20%.

Table 4. Paired samples t-test

	Paired differences			t	df	p
	Mean	Std deviation	Std error mean			
Post - Pre score	**20.137**	18.575	2.236	9.005	68	**0.331×10^{-12}**

Improvement in computational thinking

The improvement is calculated as the average percentage difference between pre and post test scores for each category of question. For example, amongst all students the category with the most improvement was the sequence category with an improvement of 23%. The overall improvement is the average of the improvement in each category.

The potential for improvement is dependant on the pre test score in that if a student achieves a very high score in the pre test then that student will get a very low improvement score. This was the case for the P5 students who from Table 3 were shown to achieve 84% score on the pre test and therefore their improvement was relatively low in Table 5 at 7%. The P1 students on the other hand, scored low in the pre test but had an improvement of 40% in Table 5.

The last 4 rows of Table 5 remove the high scoring students and focus on the low and medium performing students (with scores of less than 50% and 50-75% respectively). There were 13 students who achieved less than 50% on the pre test, but there were no students who got less than 50% on the post test. There was improvement in all students — even one student who has learning difficulties.

Table 5. Pre and post test score improvement overall and by year, gender and initial ability

	No. of students	**Improvement**			
		Seq	Nav 1D	Nav 2D	**Overall**
All students	69	23%	19%	18%	**20%**
P1	10	30%	38%	51%	**40%**
P2	16	24%	38%	35%	**32%**
P4	20	31%	11%	6%	**16%**
P5	23	11%	6%	3%	**7%**
Female	37	19%	16%	14%	**16%**
Male	32	26%	24%	24%	**25%**
<50% in pre test	13	28%	47%	64%	**46%**
50-75% in pre test	24	35%	26%	14%	**25%**
<75% & Female	15	29%	34%	28%	**31%**
<75% & Male	23	36%	32%	35%	**34%**

Key observations from Table 5:

- P1 students showed the most improvement
- 13 students got less than 50% on the pre test, but all students were above 50% in the post test.
- The low performing students (who got less than 50% on the pre test) improved their scores by an average of 46%.

- The mid range performing students (50% - 75% on the pre test) improved their scores by an average of 25%.
- Of the low and mid performing students, there was no significant difference in their improvement when compared by gender (female and male students improved by 31% and 34% respectively).

Survey of attitudes

The results of the survey are divided into 3 areas. The first area asked the students (before and after using The Foos) to choose which item they are most interested in, from 'bicycle', 'computer', 'doll/teddy' and 'elastic band' (a traditional Thai game played by children). The second area asked students if they would like to work with computers. The third area involved a set of questions to obtain their relative confidence in the subjects of 'art', 'maths', and 'computers'. If the student's relative confidence was unclear then they were marked as 'undetermined'. The results are presented in Table 6.

Table 6. Survey results before and after

		Before	**After**	**Change**
Interest	Bicycle	30	32	**2.9%**
	Computer	28	27	**-1.4%**
	Doll/Teddy	10	10	**0.0%**
	Elastic band	1	0	**-1.4%**
Job in computers	Yes	49	49	**0.0%**
	No	20	20	**0.0%**
Relative Skill Confidence	Art	20	21	**1.4%**
	Maths	26	24	**-2.9%**
	Computers	13	16	**4.3%**
	Undetermined	10	8	**-2.9%**

Observations from Table 6:

- There was no effect on the student's interest in computers, nor were they more or less likely to show any preference for working in the area of computers in the future.
- There was a small effect on students confidence of their own skill. Out of 69 students, 13 students rated themselves as better at computers than art and maths before the using The Foos. This number rose to 16 students after using The Foos.

Discussion

During the experiment, the researchers informally observed that all the students made exceptional progress over 3 one hour sessions with The Foos on iPad, to the point that students were able to complete tasks beyond the content that was envisaged to be covered by the experiment. The results from the experiment confirm the observation and quantify the increase in computational thinking across all ages and genders.

Particularly impressive is the age range of students that succeeded to solve computational problems after playing The Foos. In Table 3, the post test scores by year of study were indicative that age is not a barrier to computational thinking. The report gives strong evidence that computational thinking is attainable by early primary school grades. The researchers themselves were skeptical on whether Thai 6 year olds were ready for computational thinking -- but the data proves that they are highly capable in the areas of computational thinking tested. In terms of sequencing, one dimensional navigation and two dimensional navigation, the younger P1 and P2 student scores were only marginally lower than those of the P4 and P5 students.

A second significant observation is the role of gender in computational thinking ability. With universities struggling to recruit female computer scientists, and programming being stigmatised as a male occupation, one might expect that girls struggle with computational thinking. On the contrary, the pre test results identified that female participants significantly outperformed male participants in solving all 3 categories of computational thinking tasks. On average, female students achieved 10% higher scores than their male counterparts in the pre test. After playing The Foos, the female students achieved on average marginally higher scores than the male students, but the difference was much less significant. Overall, the results certainly refute any hypothesis that computational thinking is better suited to boys.

One of the weak parts of the results is that the tests should have been more difficult. With an average post test score of 88%, and many students achieving close to perfect scores, there was not enough potential to differentiate between the groups of students. In future studies it would be advisable to also test students on more advanced areas of computational thinking, such as ‘looping’ and ‘conditionals’.

Overall, the researchers were highly impressed with the engagement of the students with The Foos app. Not only were the students developing their computational thinking skills as quantified above, but they were also interacting with each other as much as with the iPad. In order to solve different types of computational problem, the students collaborated, shared and helped each other come to a common understanding. Whereas the use of technology in the classroom is often viewed as neglecting the social aspect of learning, our observation is that The Foos is highly successful in making the development of computational thinking skills an accessible fun social activity for all students.

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