Closing the Gap in Computing Confidence in Middle School through Creative Computing

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ABSTRACT
This paper studies the attitudes of two cohorts of middle school students in Nepal, one a group of privileged students from technology rich environments and another a group of marginalized students with limited access to computing technologies. It finds that the latter cohort is more anxious and shows less enjoyment while using computers compared to their peers exposed to technology rich environments. Taking Creative Computing, a making-oriented after school program implemented in two schools in Nepal as a case study, this paper proposes exploring three threads. First, the impact of the after school computing program on students' attitudes towards computing. Second, the impact on the gap in self-reported enjoyment/anxiety around computing between the two cohorts. Third, it seeks to gather qualitative data on attitudes towards computing in the local context by conducting interviews with participants in the making based after school program. The results of the study will inform the design of programs that seek to promote inclusivity in the ICT sector through computing education.

Keywords
Computational Thinking, Game Design, Physical Computing, Skill gap, Nepal, Inclusivity

1. INTRODUCTION
Familiarity with computing and computers is widely recognized as a critical component of employability and success in the 21st century. While popular belief holds that the generation currently in school is technology friendly, familiarity with the use of computing devices may not equal the ability to use them effectively. As noted by Partner4CS [11]

Despite the wide availability of technology in teenage life, recent data suggests that most teens are limited to using technology while only a small number of teens have the skills required to create computing innovations. There is an increasing emphasis on helping all students acquire a deeper understanding of aspects of computing, solve real world problems and understand human behavior by drawing on Computational Thinking.

Cuny (2010)[6] defines Computational Thinking (CT) as "the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent." Thus, CT is a critical skill necessary in the information age. The Nepali national curriculum is, however, prescriptive and rigid, focusing on learning procedures rather than thinking patterns [10]. This combined with a lack of teachers with sufficient computing experience and expertise reduces the effectiveness of the computing education.

In this study, we examine 'Creative Computing', an after-school program designed by Karkhana, to establish whether it is effective in closing the confidence and enjoyment gap in computing between students from expensive private schools and urban government-funded schools. Karkhana is an education company and a makerspace that designs and delivers project-based STEAM (Science, Technology, Engineering, Arts and Maths) curriculum to middle school students. We pick urban government-funded schools in the Kathmandu Valley because they largely serve socioeconomically marginalized groups with limited access to a technology rich experience but often have a computer lab in school. We are studying urban, rather than rural government schools, as the latter often lack access to basic infrastructure such as electricity, internet and local mentors. Our emphasis is not on examining access to computing, but on equitable competency after in-school access has been realized.

2. THE NEPALI CONTEXT
In 2006, the seven major Nepali political forces signed a peace agreement ending 10 years of civil war. The war resulted in 13000 deaths [1] and an estimated economic loss equivalent to 3 percent of Nepal's GDP [14]. The peace accords resulted in a Constituent Assembly (CA) tasked with creating a new and inclusive constitution that provided better for Nepal's many minorities, across ethnic, linguistic, gender and regional fault lines. The CA had some early successes, such as declaring Nepal a republic and abolishing the monarchy. It was not, however, able to forge a consensus and was dissolved after 5 years.

With no clear accord on the new administrative boundaries and power sharing between various levels of government, Nepal hasn't held local body elections since 1997 [2]. In this environment, state funded schools, in particular their Management Committees, have been a place to test local political power. This has resulted in acrimonious school-level elections and the use of schools to dispense political patronage [13]. Consequently, the exodus of students out of the state-funded system into private schools, which began in the 1990's has continued unabated [5].

The 1990 revolution, which ended the absolute monarchy and brought a multi-party democracy to Nepal, led to liberalization of several sectors including education. This led to the establishment of the Private and Boarding School's Organization (PABSON), an umbrella organization for private schools, in 1991. Private schools have mushroomed ever since [16]. As of 2011, private schools constitute 20% of all schools in the country and accounted for one fourth of the total number of students in Nepal [16]. The growth of private schools resulted in a strong socio-economic stratification of education, with students of similar social status and wealth attending the same schools [4].

The performance gap between private and government schools is most apparent in the School Leaving Certificate (SLC), a grade ten national exam widely viewed as an indicator of school quality by both the general public and the government [17]. Based on a nationwide survey of SLC results in 2002, 2003 and 2004, the pass rates for private and public school students are at 87.20% and 45.12% respectively [17]. The mean score for the SLC is 60.30 for private schools and 43.25 for public schools, a gap of 17.05 [17].

3. CONTEXT OF THIS STUDY

In addition to poor performance on standardized testing, state-funded schools are not up to the task of preparing students to meet their aspirations of 'respectable' employment [3]. Skill focused technical/vocational programs largely seek to reinforce existing social divides by compelling students without the means to afford a "good" education back into blue-collar professions.

Positive attitudes towards computing may be one critical piece to breaking this cycle. For a small number of students with a strong propensity for computational thinking, there are opportunities in the nascent, growing and skill-deprived software sector. For the rest, feeling confident about computing and developing an ability to manipulate information-processing agents remain a critical skill for white-collar 21st century jobs [15].

While no other actor can match the scale of public schools, after school programs to supplement in-class courses are the best available approach in the face of entrenched problems plaguing the government-funded system. This approach is valuable because it circumvents

1. a too rigid and prescriptive curriculum that does not reflect market realities.

2. the issues around teacher motivation and the political landmines of navigating the regular school system.

3. the lack of teachers qualified and trained for ICT education [19].

While the intervention can be staged at any education level, we explore the effectiveness of a middle school program as that time is crucial to influencing decisions about careers in computing [11]. Policy changes afoot also make a middle school focused study useful. Since 2013, the Government Of Nepal has piloted a "technical" vocational program in 99 schools around the country. One of the tracks of study is Computer Engineering, which will eventually run from grades 9-12 [7]. An effective middle-school program would, therefore, serve two purposes. Namely, it would

1. help students discover their interest in pursuing a more computing focused career.

2. identify students with a propensity for CT, who might be directed towards the technical track.

4. METHODOLOGY

In order to document potential changes in students' attitude towards computing we administered the Computer Attitude Questionnaire (CAQ) [8] as the pre-intervention survey. The CAQ is based on a Likert type scale intended to be used in a middle school environment [8]. The CAQ developed Knezek and Rhonda (1996) collected data from 588 students in a Texas public high school to validate the construct and criterion-related validity of the CAQ [8].The CAQ has also been previously used in an international context in Malaysia [12] and for a four nation survey in 1998 [9].

4.1 Selecting Students

The Creative Computing after school program is run in 2 cohorts. Cohort 1 is socioeconomically privileged children from technology rich households; Cohort 2 is socioeconomically marginalized government school students.

The 22 students surveyed as part of cohort 1 are enrolled in Karkhana's after school enrichment program. They are between the ages of 11 and 15, and attend 11 different schools. These student attend "premiere" institutions with tuition costs that fall in the upper 10% of Nepali schools. They are also self-selected as the program is optional, relatively expensive and requires parents to pick-up/drop-off children on a holiday. Thus, these students are both interested in computing and come from environments where their interest is supported.

Cohort 2 consists of 38 students currently in grade 8 at BBK, a government school in the Kathmandu Valley. The program is optional and free of charge. The regular classes in the school run from 6.50 AM to 10.50 AM, thus attracting many students with work and family obligations after school. A significant number of students at BBK work after school, and many report very limited time for study and homework.

It is extremely rare for middle schools students from private schools to have an after school responsibilities that distract from their homework. It is somewhat more common for students in normal urban government schools, that run from

Table 1: Students in cohort 1 and cohort 2 according to gender

	Male	Female	Total
Cohort 1	17	4	21
Cohort 2	15	20	35
	32	24	

10 AM - 4PM, to have significant domestic or income generating responsibilities. BBK represents an extreme case even within this pool as it's early morning class hours lend themselves to a near full-time job.

Given these pressures and past experience, we anticipate a regular attendance of approximately 24 students from this cohort with 4-6 students attending over 60% of sessions. The school has a total of 15 computers in a computer lab for 180 students and they have 3 hours of computer classes every week. They do not, however, have a backup power system which makes predictable use of the computers difficult.

The student selection analysed according to gender in Table 1 shows that the cohort 2, the government school, has more girls than boys. Thus our program also reflects the underlying dynamic of having more girls than boys in government schools of Nepal. Tracking the dropout rates and attendance by gender in cohort 2 will be a good indicator on female participation in the program.

In cohort 1, Karkhana's after school enrichment program, a significant gender imbalance is seen. Since this program is attended by choice, and has high costs (in time and money) associated with it, it appears parental and student inclinations follow the existing gender stereotypes of having fewer girls in computing programs.

In the Nepali context it is also important to track diversity and inclusivity through the lens of caste. The study did not ask for any data on caste, but we strongly feel that future studies should take caste into account.

4.2 Selecting Instructors

Cohort 1 and 2 will be instructed by the same two 2 teachers. **H** is an Electronics and Communications engineer, with a Masters degree. He worked at a large global tech company outside Nepal before turning to teaching. He has 6 months of teaching experience working with middle school students and a year of experience teaching at an Engineering Bachelors program prior to that. **R**, also an engineer, has just over 2 years of experience teaching middle school. **R** has a deep love for programming and technology. He codes in several languages, is teaching himself how to use special effects/animation software in his spare time and tinkers with hardware (he has cloned the makey-makey to find a cheaper alternative for use with his students).

Instructor selection for this study was done from a limited and restrictive pool of sufficiently qualified teachers working within Karkhana. Thus both instructors are male, from high-caste and relatively economically privileged backgrounds. As Karkhana's pool of teachers becomes more representative and diverse, we intend to conduct future studies with more diverse range of instructors. And explore the importance of this variable to the research outcomes.

4.3 Translating Questionnaires Into Nepali

Cohort 1, consisting of students mostly attending "premiere" private schools in the city, were administered the questionnaire in English. For Cohort 2, the 38 students from the government school BBK, the questionnaire was translated into Nepali.

Attempting to create an equivalent translation is a difficult job and depends upon the translator's ability to be consistent in identifying and correcting incomprehensible and irrelevant translated items [18]. Van Ommeren et al. (1993), in translating instruments for Nepali speaking Bhutanese refugees in the United States, suggested several processes to ensure cultural relevance. We followed comprehensibility and relevance, two out of four established standards.

A group of bilingual teachers with computing experience initially reviewed the survey in English. They identified several statements that could not be literally translated, e.g. "Using a computer gives me a sinking feeling," which were marked for the translator's special attention. An experienced translator was engaged to make a first draft Nepali translation. The draft was carefully reviewed by the same group of teachers for strange, garbled or culturally insensible translation. Take the sentence "use of computers make me nervous." This simple, straight forward sentence had not caught the review team's eye in the first round.

On review, however, the team felt the word chosen to convey nervousness was inappropriate and confusing. Rather the team opted for a simpler, commonly used Nepali word that conveys a mixture of nervousness and hesitation. The feedback and suggestions of the review team were communicated to the translator, who then made changes. The second copy of the translation went through review with no issues identified as substantive enough to warrant a third reworking.

4.4 About Creative Computing

Creative Computing is a 12 week after school program where the final objective is to build a physically interactive computer game. The program involves implementation of a range of activities that help students develop their CT. There are several programs that teach CT concepts to middle school students such as Mouza et. al (2010) which uses Scratch, a Visual Programming tool created by MIT's Media Lab. Karkhana's CC program also uses Scratch for programming, but introduces sensing and physical computing to the students through Arduino, an open-source electronic prototyping platform allowing to create interactive electronic objects and A4S (Arduino 4 Scratch), an open source extension that connects the physical world to the digital world.

Creative Computing classes start with a project prompt. Students are transported a 100 years into the future where the world is in crisis due to an epidemic of addiction to computers, cell phones and gaming consoles. Human race is facing extinction from obesity as people get little or no physical exercise due to their addiction to the devices. Over the 12 week period of the workshop, students need to create

Table 2: Difference in Computer Attitudes between cohort 1 and cohort 2 Students

Category	C2 Mean	C1 Mean	Mean diff	C2 Std Dev	C1 Std Dev	t-value	df [1]	p-value	ES1	ES2
Computer Importance	3.6000	3.3500	0.2500	0.7133	0.6778	3.4017	303.0640	0.0007	0.4000	-0.4000
Computer Enjoyment	3.0100	3.4200	-0.4100	0.9433	0.7127	-5.035	417.8170	< 0.0001	-0.6000	0.4000
Computer Anxiety	2.7400	3.2400	-0.5000	0.9700	0.8800	-5.1766	324.2350	<0.0001	-0.6000	0.5000
Computer Seclusion	3.2300	3.0400	0.1900	0.8826	0.8143	2.7619	604.3900	0.0059	0.2000	-0.2000

a game that enables people to get some physical exercise while they are still on their computers.

The skills taught through the workshop can be divided in roughly 4 major categories: i. programming and computational thinking, ii. presentation and communication, iii. electronics and sensing and iv. fabrication and woodworking.

The opportunities for learning presented by combining these four categories of skills are greater than those garnered by practicing the skills individually. For e.g. a group of students in cohort 1 chose to make a multi-player racing game for their final project. Initially the game only used keyboard input. The prompt dictated that they make the game physically interactive, so the group decided on integrating steering wheels made out of wood into their game. The group explored various sensing options before settling on a potentiometer. They attached the steering wheel into the potentiometer, so that turning the wheel would produce a change in the resistance. The code was modified in order to accomodate the sensing capabilities of the potentiometer. The bigger change in resistance would produce a bigger turn and a small change would produce a smaller turn. After receiving feedback from the peers that the game would be lot more exciting if they had accelerators and brakes along with the steering wheel, they incorporated foot accelerators for the cars using push button switches. This last change required fabrication, further code changes and presented additional opportunities to communicate their work to an audience of their peers.

5. POST INTERVENTION STUDY

After the completion of the Creative Computing program the students will again be administered the same Computer Attitude Questionnaire [8] to see if the program brought about any change in the students' attitudes towards computing. Post-CC results of both cohorts will be compared to see the intervention's impact on the gap between the two cohorts. Furthermore we will run semi-structured interviews with the teachers and a random sampling of students to gather first-person reflections.

[1]df=degree of freedom
[1]ES1 = Effective Size with Cohort 1 as control
[1]ES2 = Effective Size with Cohort 2 as control

Pre-intervention data collection, as reported in Table 2, showed that there are statistically significant differences in attitudes towards computing between the two cohorts.

Cohort 2, the students from the government school BBK, identify computing as more important to the quality of their learning and their employment prospects. However, they were also more anxious about computer use, and reported that they enjoyed using a computer less than their peers in cohort 1.

While enjoyment scores reported by both groups were fairly high, the effect size for enjoyment (.4/.6 depending on which cohort was considered the control) indicates a large difference between the two groups. Anxiety with computer use was the most divergent among the 4 categories considered. It had the highest mean difference (.5) and showed the greatest effect size (.6/.5). Though cohort 2 considered computing and computers to be more important, their limited access and support in using computing devices seem to have resulted in higher anxiety and reduced enjoyment in computer use.

6. DISCUSSION

Given the findings discussed above, it is important to explore the Creative Computing after school program from two perspectives. First, we want to find out if after school programs can increase computing enjoyment and reduce anxiety. Mouza et. al [11] have shown that after school programs can be effective in increasing computing confidence. This study will help verify if these findings hold true in Nepal, where the cultural and educational context are different. Second, and more importantly, we want to explore the impact this after school program will have on the gap between the two groups of students, one privileged and the other marginalized by the prevailing socioeconomic conditions. With many coding/computing interventions available to teachers, policymakers and grantmakers, the value of taking an evidence-based approach to program implementation is immense.

Furthermore, qualitative data on prevailing attitudes towards computing in Nepal is important. As a so-called peripheral economy, Nepali attitudes, expectations towards modern technology and beliefs about their applicability are ill-examined and poorly documented. Thus, developing a rich data set of qualitative, first-person data will aid tremendously in creating inclusive and equitable programs.

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