Classroom Versus Screencast for Native Language Learners: Effect of Medium of Instruction on Knowledge of Programming

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ABSTRACT

Students, who study in their native language in K-12 and go on to do their undergraduate education in English, have difficulty in acquiring programming knowledge. Solutions targeted towards improving their English proficiency take time, while those that continue with native language in the classroom limit the students' ability to compete in a global market.

Another solution could be the use of video-based instructional material to empower a student for self-paced learning. In this paper, we present a comparative study of classroom instruction versus self-paced screencasts for native language learners' acquisition of programming concepts. We conducted four introductory programming workshops, each of six days duration. Two workshops were classroom based, one having Hindi (native language) as the medium of instruction and other in English. Two other workshops were screencast based, again one in Hindi and one in English.

We measured differences between the groups using a post-test, across different content types such as fact, concepts and process. We found that when medium of instruction is different from language of K-12 instruction, there is an adverse impact on learning. However, when self-paced screencast is used instead of classroom environment, there is a statistically significant improvement in performance. Our work informs the choice of MoI and choice of environment for native language learners.

Categories and Subject Descriptors

K.3.2 [**Computers and Education**]: Computer and Information Science Education - *computer science education*.

Keywords

Computer programming education; screencast; native language instruction

1. INTRODUCTION

Students who study in their native language in K-12 and go on to do their undergraduate education in English, have significant difficulty due to the language barrier [1], leading to high drop-out rates[2].

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Attempts to overcome this barrier by either (i) improving English proficiency, or (ii) continuing with native language instruction, have limited success. This is because acquiring English proficiency takes time [3], while continuing with native language limits their social context of choice [4].

Another solution to this difficulty is the use of video-based instructional material that empowers the student for self-paced learning. With present day technology, creation of such videos has become easy and affordable. Videos can be created in several ways, for example, classroom lecture video, talking head and screencast [5]. However there are not many studies that examine the effectiveness of video-based material in the context of native language learners, few studies are reported in [1].

In this paper, we present a comparative study of classroom instruction versus self-paced screencasts for native language learners' acquisition of programming concepts. While there is work on the use of native language for classroom teaching of programming [10] and computer science subjects[6][8][9], there is no experimental data that compares the impact of classroom versus screencast, as well as the effect of medium of instruction (MoI), on student achievement. Towards this end, we conducted the following study.

We created four introductory programming workshops (W1-W4), each of six days duration. W1 was classroom based and had Hindi (native language) as the MoI. W2 was also classroom based but had English as the MoI. W3 was screencast based with Hindi as the MoI. W4 was also screencast based but had English as the MoI. Our sample consisted of first year undergraduate engineering students, some of whom had K-12 instruction in English while others had K-12 in Hindi. They were divided into groups, as shown in Table 1. The topics were taken from ACM CS curriculum [10], as shown in Table 2.

Table 1. Detail of participating groups

Environment	Work-shop	Medium in K-12	MoI of workshop	Name of Group	N
Classroom	W1	Hindi	Hindi	HHc	35
	W2	Hindi	English	HEc	35
		English	English	EEc	35
Screencast	W3	Hindi	Hindi	HHs	35
	W4	Hindi	English	HEs	35
		English	English	EEs	35

Table 2. Topics of each day screencasts

Topic number	Subtopics of each day (comma separated)	Day
T1	Introduction to programming, program, development process	1
T2	Identifiers, data type, memory representation, integer, use of variable.	2
T3	Arithmetic instructions, operators, operators precedence	3
T4	printf, scanf	3
T5	Relational operators, equality operators, branching statement, if, if-else	4
T6	Functions, Function call, pass by value, return types	5
T7	Recursion	6

We measured differences between the groups using a post-test of 59 items, across different content types such as fact, concepts and process. For classroom environment, we found that the difference between the experimental group (HHc) and control group (HEc) was statistically significant with moderate effect size, thereby confirming that when MoI is different from language of K-12 instruction, there is an adverse impact on learning. On the other hand, the difference between experimental group (HHc) and baseline group (EEc) was not significant. This shows that when the MoI is the same language as in K-12 instruction, there is no adverse impact on the learning, in classroom environment.

For classroom versus screencast, we found that the difference between the control group (HEc) and experimental group (HEs) was statistically significant, with moderate effect size. We also found that the difference between HHc versus HHs, as well as difference between EEc versus EEs, were not significant. This implies that when MoI is different from the language of K-12 instruction, the use of self-paced screencast is desirable. Thus our work informs the choice of MoI and choice of environment for native language learners.

In Section II we present the related work on teaching programming through native language instruction. In Sections III and IV, we give the details of our research questions and methodology, respectively. The results are in Section V, followed by discussion in Section VI.

2. RELATED WORK

Benefits of native language instructions in mathematics [11] and physics [12] are reported in the studies. In a work [6] authors suggested a bilingual model for teaching programming in China, but it is still being implemented and no experimental data is available.

Screencast have several benefits over traditional classroom including low cost and high availability [14]. Students in a traditional classroom are unable to concentrate after 20 minutes [15]. Screencast enables self-paced learning so students can maintain their level of concentration by breaking the lecture into smaller chunks [16]. Students can rewind and replay the screencast if they miss any part of the material [16]. Also, sometimes in classroom, the distance from instructor makes it difficult for students to focus and creates distractions. While self-paced screencasts create the impression that a learner is sitting quite close to the lecturer [16]. In traditional classroom students tend to focus on taking notes for later use, while in screencast they do not focus on note-taking but on understanding concepts [16]. Also, the classroom environment is more difficult for learners who are studying in a foreign language, as they have to understand the content and language at the same time [18].

In a pilot study conducted by Simpson [16], students self-reported that they prefer screencasts over traditional classroom environment. Students who were part of the study also found video player controls acting as a scaffold for better learning. One study on statistics [13] found that students watching screencast took less time to study and performed better than those who were receiving text-based instructions.

While students and teachers agree that screencasts should be created in native languages [19], there is no work on the effect of native language screencasts on student achievement, in the context of programming. Moreover, there is no study that compares the performance of students in classroom versus screencast in the native language. In this paper we address these gaps. We study the effect of medium of instruction on acquisition of programming knowledge by native language learners, in both classroom and screencast settings.

3. RESEARCH QUESTION

We use the term “medium” to denote the medium of instruction in K-12 years of schooling. In our experiment, the medium could be the same as the native language (Hindi) or different (English). We use the term “MoI” to denote the medium of instruction in the treatment. In our study, the MoI for the screencast or classroom is either English or Hindi.

By using screencast in classroom we want to say use screencast in classroom rather than live lecture or screencast at home.

We are answering three major questions. First major question is: What is the impact of the MoI on the programming abilities of native language learners in classroom? This is operationalized into the following specific question:

Do undergraduate Hindi medium students learning introductory programming in classroom in Hindi perform better than similar students who learn programming in Classroom in English?

Second major question is: How does moving from classroom to screencast affect the performance of students? This is operationalized in the following question:

Do undergraduate Hindi medium students learning introductory programming by watching Hindi screencast perform better than similar students who learn programming in Hindi in Classroom environment?

Our third major question: How does medium of instruction affect the performance of native language students, for both classroom and screencast?

Do undergraduate Hindi medium students learning introductory programming by watching English screencast perform better than similar students who learn programming in English in Classroom environment?

4. METHODOLOGY

4.1. Sample

The sample consisted of 210 engineering 1st year undergraduate students of North India. The sample was divided into 6 groups according to their prior medium of instruction, medium of instructions in the treatment (MoI) and treatment environment (classroom or screencast), as shown in Table 1.

We included only those learners who are studying programming in their current semester. Moreover we used purposive sampling, i.e., participation was made voluntary thereby excluding students who are not interested in learning programming. Further, we selected only those students who had no or little prior knowledge of programming. We ensured equivalence of the groups on prior academic achievement.

4.2. Instruments and Data Collection

To measure programming ability, performance scores on a post-test were collected. To determine prior knowledge of programming a 10-item pre-test was conducted. To determine

prior academic achievement levels, overall percentage of marks in 12th grade final examination were collected.

We used a 3-item survey to collect data about students' background. The items for each student were: (i) MoI in 12th standard (English or Hindi), (ii) Overall percentage of marks in 12th standard, and (iii) Whether they have prior knowledge of programming (yes or no). We verified their self-reported knowledge of programming using the pre-test.

We used paper-based post-test every day after workshop. We looked for a concept inventory for programming but found that the standardization of assessment instruments for programming ability is still ongoing [20]. So we created the post-test based on questions that typically appear in the University exams and those given in standard textbooks. We included only those questions that directly mapped to the learning objectives in our screencasts. There were 59 items in the post-test, 44 multiple choice, 7 short answer questions, 3 write a program and 5 matching type questions. Also, 22 of the 59 items were on factual knowledge, 31 on conceptual knowledge and 6 were on knowledge of process. One sample post-test question from each category is given in Table 3.

Table 3. Sample post-test questions from each category

Checking knowledge of	Sample Question
Fact	**Q4. \n & \t are** a. Keywords b. Escape Sequence c. Format Specifier d. None of the above
Process	**Q1e. What will be the control flow of given program?** a. 9, 10, 11, 3, 4, 5, 6, 11, 12 b. 3, 4, 5, 6, 7, 9, 10, 11, 12, 13 c. 9, 10, 11, 12, 13, 3, 4, 5, 6 d. Other please write .....
Concept	**Q11. Value of L if?** **L = 6 != 5** a. 6 b. 5 c. 1 d. 0 e. Other please write .....

4.3. Procedure

Survey: We first conducted the survey and then divided the students into 6 groups, based on the medium of their 12th Std, as shown in Table 1. We compared the means of the 12th Std marks for the groups and found them to be equivalent. We did ANOVA to confirm the equivalence. We also conducted a pre-test after survey with the selected students. We removed all students who got more than 40% marks in pre-test because we wanted to include only those who had either no or little knowledge of programming.

Arrangement for screencast based treatment: We arranged separate computer lab for the three groups. In lab each computer was equipped with headphone and media player was installed on each computer in advance.

Arragement for classroom based treatment: We arranged two different classes. MoI of one class was English which was conducted for HEc and EEc groups. MoI of other class was Hindi which was attended by HHc group.

Treatment for screencast: Each student was alloted one computer. Each student watched screencast on the alloted computer in computer lab. Each computer was equipped with headphone so that students can not hear outside noise. Students were allowed to watch screencast for 45 continuous minutes. They were free to use video player controls according to their need. Shortest screencast is 22:00 minutes in length and longest is 45:00 minutes. There were no additional tutorials or laboratory exercises. The topics of the screencast of each day are listed in Table 2.

Treatment for classroom: The class that was conducted in English was attended by HEc and EEc groups. Both groups were sitting in different rows. HHc group attended the classroom that was in Hindi. There were no additional tutorials or laboratory exercises. The topics of the classroom of each day were same as screencast and listed in Table 2.

Slides and live coding [21] was used in screencast as well as in classroom. We used digital pen in both environment so that teacher can draw diagrams, symbols and other necessary things on screen. Figure 1 shows an example of using digital pen with live-coding method. Slides were completely in English for all six groups. The explanation was in Hindi for HHc and HHs groups and English for EEc, EEs, HEc and HEs groups. Screencasts and classrooms in two languages were identical in terms of explanation, source-code, examples and analogy. Sample screenshots of the material are given in Figure 1 and Figure 2 Note that only the vocal explanation is in Hindi for the HHc and HHs groups.

Figure 1. A screenshot that shows use of digital pen-tablet.

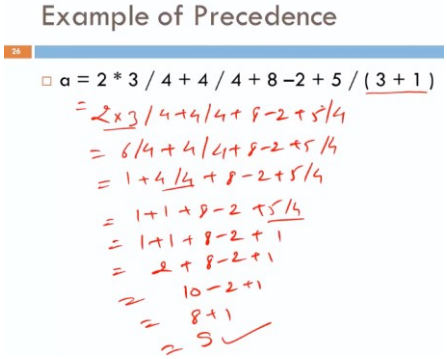
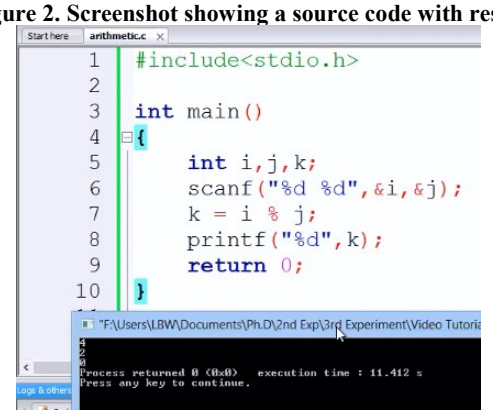


Figure 2. Screenshot showing a source code with result



Screencast and classroom of each day for each group addressed the same Learning Objectives (LOs). The list of LOs is given below in Table 4.

Table 4. Learning objectives of screencasts

LO number	Learning Objective
LO1	Analyze and explain the behavior of simple programs involving the fundamental programming constructs covered by this unit.
LO2	Identify and describe uses of primitive data types.
LO3	Write programs that use each of the primitive data types.
LO4	Modify and expand short programs that use standard conditional structures and functions.
LO5	Design, implement, test, and debug a program that uses each of the following fundamental programming constructs: basic computation, simple I/O, and standard conditional, the definition of functions, and parameter passing.
LO6	Choose appropriate conditional constructs for a given programming task.
LO7	Describe the concept of recursion and give examples of its use.
LO8	Identify the base case and the general case of a recursively-defined problem.
LO9	Identify and describe the use of standard conditional structures and functions.

Posttest: To investigate the effect of the MoI on achievement scores, we conducted a post-test everyday after the treatment using the instrument we had designed earlier. Each student had to attempt the posttest individually, within a time limit of fifteen minutes. There was no negative marking.

Analysis: We performed quantitative analysis of the post-test scores for the different groups and question categories. We computed the means for each group. We used one-way ANOVA to compare groups to determine which means are stastically significantly different from one another.

5. Result Analysis

The mean of post-test scores (out of 59) for the six groups (HHs, HEs, EEs, HHc, HEc and EEc) are shown in Table 5.

Table 5. Mean of post-test scores for all groups

Group	N	Mean	Std. Deviation	Std. Error of Mean
HHs	35	45.00	7.472	1.263
HEs	35	37.57	5.937	1.004
EEs	35	42.51	5.511	.932
HHc	35	43.14	7.781	1.315
HEc	35	27.86	8.229	1.391
EEc	35	42.00	8.578	1.450

Mean of scores for HHc group and the EEc group is higher than the HEc group, and the mean of scores for the HHs and EEs group is higher than the HEs group (see Table 5). This indicates that for both environments Hindi medium students who get the treatment in English performed lower than other students. HHc, HEc and EEc group perform lower than HHs, HEc and HEc respectively (see Table 5). This indicates that students who study in self-paced screencast based environment perform better than those who study in classroom based environment.

The distribution of percentage of post-test scores for all three categories of questions, fact, process and concept is presented in Figure 3, Figure 4 and Figure 5 respectively.

Figure 3. Percentage of post-test scores of fact type questions

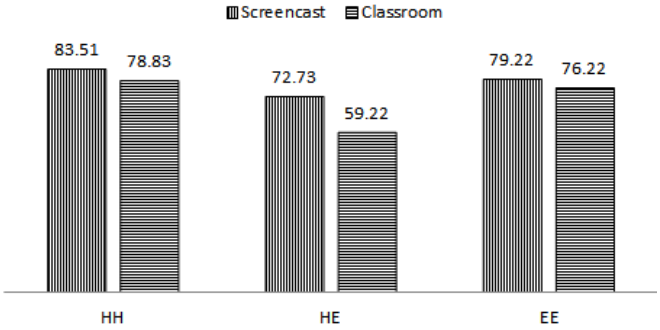


Figure 4. Percentage of post-test scores of process questions

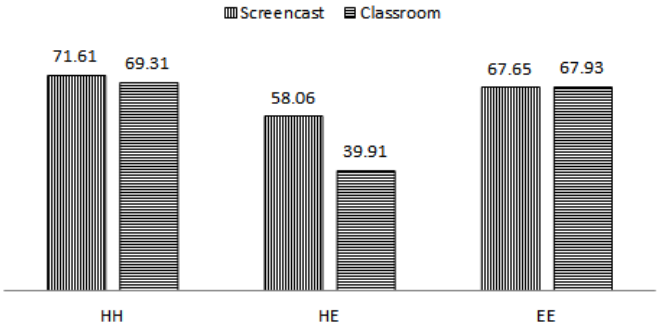
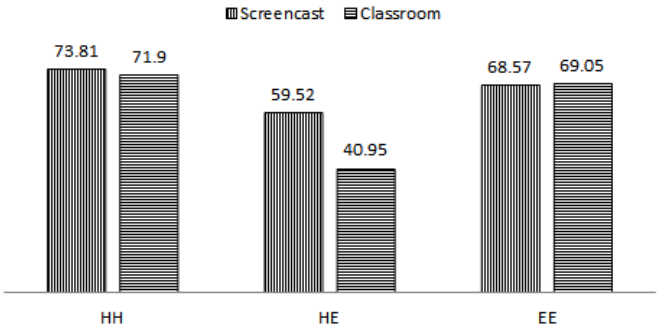


Figure 5. Percentage of post-test scores of concept questions



5.1. Comparison of HHc and HHs groups

We performed one-way ANOVA [23] to compare HHc and HHs groups and found no significant difference in total score as well as in all three question categories, as shown in Table 6.

Table 6. One way ANOVA for HHc and HHs groups

		Sum of Squares	df	Mean Square	F	Sig.
Fact	Between Groups	18.514	1	18.514	2.656	.108
Process	Between Groups	.229	1	.229	.111	.740
Concept	Between Groups	8.929	1	8.929	.471	.495
Total	Between Groups	60.357	1	60.357	1.037	.312

5.2. Comparison of EEc and EEs groups

We performed one-way ANOVA [23] to compare EEc and EEs groups and found no significant difference in total score as well as in all three question categories, as shown in Table 7.

Table 7. One-Way ANOVA for EEc and EEs groups

		Sum of Squares	Df	Mean Square	F	Sig.
Fact	Between Groups	6.914	1	6.91	.822	.368
Process	Between Groups	.014	1	.014	.009	.923
Concept	Between Groups	.129	1	.129	.007	.934
Total	Between Groups	4.629	1	4.63	.089	.766

5.3. Comparison of HEc and HEs groups

We compare HEc and HEs groups by performing one-way ANOVA [23] and found statistically significant difference in total score (effect size 0.56) as well as in all three question categories, as shown in Table 8.

Table 8. One-Way ANOVA of HEc and HEs groups

		Sum of Squares	df	Mean Square	F	Sig.
Fact	Between Groups	154.514	1	154.51	18.60	.000
Process	Between Groups	21.729	1	21.73	12.82	.001
Concept	Between Groups	554.414	1	554.41	34.52	.000
Total	Between Groups	1651.429	1	1651.43	32.08	.000

5.4. Comparison of HHc and EEc groups

We performed one-way ANOVA [23] on post-test scores of HHc and EEc groups and found no significant difference in total score as well as in all three question categories, as shown in Table 9.

Table 9. One-Way ANOVA of HHc and EEc groups

		Sum of Squares	df	Mean Square	F	Sig.
Fact	Between Groups	5.157	1	5.16	.650	.423
Process	Between Groups	.514	1	.514	.274	.603
Concept	Between Groups	3.214	1	3.214	.153	.697
Total	Between Groups	22.86	1	22.86	.341	.561

5.5. Comparison of HHc and HEc groups

We performed one-way ANOVA [23] on post-test scores of HHc and HEc groups and found significant difference in total score (effect size 0.69) as well as in all three question categories, as shown in Table 10.

Table 10. One-Way ANOVA of HHc and HEc groups

		Sum of Squares	df	Mean Square	F	Sig.
Fact	Between Groups	325.73	1	325.73	43.53	.000
Process	Between Groups	60.36	1	60.36	31.04	.000
Concept	Between Groups	1453.73	1	1453.73	69.47	.000
Total	Between Groups	4088.93	1	4088.93	63.76	.000

6. DISCUSSION AND CONCLUSION

From Figures 3-5, we observe that the performance of HEc group is the lowest among all the groups, while HHs group is the highest, for all categories of questions. This reconfirms the fact that classroom based instruction in English is not suitable for native language learners. On the other hand, while classroom based instruction in native language is suitable, self-paced screencasts in native language lead to maximum performance.

Within a classroom environment, the difference between HHc and EEc is not statistically significant (Table 9), showing that the language of instruction does not matter when MoI is matched with medium of K-12. This also confirms that the classroom lectures in both languages were equivalent. The difference between HHc and HEc groups is statistically significant with effect size 0.69 (Table 10), showing that native language learners are at a disadvantage when MoI is not matched with their medium of K-12.

Within a screencast environment, in a previous experiment [24], we found that the difference between HHs and EEs was not statistically significant, while the difference between HHs and HEs was significant. Thus, in both settings (classroom as well as screencast), we conclude that native language learners perform comparable to English medium learners, when they continue to learn in their native language, but are unable to do so when forced to learn in the secondary language.

When we compare groups within the same medium of instruction, we find that the difference between HHc and HHs groups is not statistically significant (Table 6), and the difference between EEc and EEs is also not significant (Table 7). This leads to the conclusion that the environment (classroom versus screencast) does not play a role in performance if MoI and medium in K-12 are the same. On the other hand, the difference between HEc and HEs groups is statistically significant (effect size 0.56) for total post-test score as well as all categories of questions (Table 8). This indicates that when MoI is different from medium of K-12 instruction, the environment plays a role in the performance. Thus we conclude that if MoI is mis-matched for native language learners, then it is better to use self-paced screencast rather than a classroom setting.

One limitation of our study is that our sample was from cities where standard of education is higher than towns and villages. Conducting the same experiments on sample from small towns and villages is required to further generalize our results.

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