A Framework for Scaffolding to Teach Programming to Vernacular Medium Learners

Submitted in partial fulfillment of the requirements
of the degree of

Doctor of Philosophy

by

Yogendra Pal

Roll no: 10438001

Supervisor:
Prof. Sridhar Iyer (IIT Bombay)

Inter-Disciplinary Program in Educational Technology

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY
2016

Dedication Sheet

Dedicated to my parents, *Shri Ram Prakash Pal* and *Smt. Geeta Kumari*, and to my wife, *Shalu Pal*.

Thesis Approval

This thesis entitled A Framework for Scaffolding to Teach Programming to Vernacular Medium Learners by Yogendra Pal is approved for the degree of Ph.D.

Examiners

____

Venkatesh V. Kamat

____

____

Supervisor(s)

____

Prof. Sridhar Iyer

Chairman

____

Anirudha Joshi

Date : July 19, 2016

Place : IIT Bombay, Mumbai

Abstract

Students, who study in their primary language in K-12 and go on to do their undergraduate education in English, are known as vernacular medium students. Vernacular medium students face difficulty in acquiring programming knowledge in English medium of instructions (MoI). Solutions targeted towards improving their English proficiency take time while continue teaching in primary language MoI limits the students' ability to compete in a global market. The key challenge is in developing a framework that helps vernacular medium students to comprehend the educational content presented in English MoI. It will not only help them to develop content knowledge but increase English competency also.

In this thesis, we address the problem of primary language learners in learning computer programming in English MoI. In our solution approach, we first identify the problems of vernacular medium students from the literature review and then reconfirm them in Indian context using a qualitative study. We identified and tested language based scaffolds, cognitive scaffolds, and the environment in which these scaffolds work.

This thesis presents five research cycles which were used to identify, select and test the effectiveness of various scaffolds to teach programming to vernacular medium students. The research cycles produced five different prototypes. Each prototype use different set of scaffolds in learning material, learning environment and presentation. Learning material for each prototype was selected or designed to reduce the cognitive load of students and provide language-based scaffolds. We used two different educational environments, 1) classroom environment and 2) self-paced video-based learning environment to test our prototypes. Visualization guidelines to teach various content types and multimedia principles are followed to reduce the cognitive load of students.

Cognitive scaffolds to reduce intrinsic cognitive load are identified from instructional design principles and visualization guidelines to teach various educational content types. We found that instructional design principles help in writing learning objectives and decide prerequisites. Use of instructional design helps in the systematic planning of instructions that removes instructional gaps and help learners to comprehend the presented learning material by reducing the intrinsic cognitive load. Visualization guidelines to teach various educational content types (e.g. fact, process, concept, procedure, and principle) helps in design instructions that reduce the intrinsic cognitive load of vernacular medium students. We selected and tested multimedia principles that reduce the extrinsic cognitive load of vernacular medium students. These principles are split-attention effect, segmentation, pre-training, synchronization, redundancy effect, verbal redundancy and attention cueing.

We identified several language based scaffolds that reduce the mental effort of a vernacular-medium student that are used to translate the educational content presented in English only MoI. These language-based scaffolds are 1) Use of simple English MoI, 2) Explain semi-specialized and specialized words on the first occurrence, 3) Use of slow pace for vocal explanation. We also identified language-based scaffolds for bilingual MoI when classroom based environment is used, these scaffolds are 1) Use of simple Hindi MoI for vocal explanation, 2) use of code-switching, 3) Use of English MoI for specialized and semi-specialized words.

We conducted two qualitative studies, and three quantitative studies to measure the effectiveness of various scaffolds. We used classroom based environment in two research cycles and self-paced video-based learning environment in three research cycles. We find that self-paced video-based environment is more suitable for vernacular medium students than a classroom environment if English only MoI are used.

The main contribution of this thesis is 1) identification of language-based scaffolds that help in comprehending the educational content presented in English only MoI and bilingual MoI 2) a framework that helps teachers to plan instructions to teach vernacular medium students based on various conditions 3) the selection of visualization guidelines and multimedia principles to provide cognitive scaffolds.

Keywords: Bilingual education, CLIL, teaching programming, scaffolding framework, English only medium of instructions, bilingual medium of instructions

Content

List of Figures

List of Tables

Abbreviations used in this thesis

CBSE	:	Central board of secondary education
ICSE	:	Indian Certificate of Secondary Education
CLIL	:	Content and language integrated learning
ESL	:	English as second language.
MoI	:	Medium of instructions.
ICT	:	Information and communication technologies.
SME	:	Subject matter expert
EDR	:	Education design research
ZPD	:	Zone of proximal development
MOOC	:	Massive open online course
IDE	:	Integrated development environment
CLT	:	Cognitive load theory
RC	:	Research cycle
NME-ICT	:	National mission on education through ICT
GUI	:	Graphical user interface
GCC	:	GNU C Compiler

Declaration Sheet

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

____
(Signature)

____
(Name of the student)

____
(Roll no.)

Date: ________________

Chapter 1

Introduction

India has 29 states and 7 union territories, each state is characterised with a local language for colloquial and administrative use. Hindi, Bengali, Telugu, Marathi, Tamil, Urdu, Gujarati, Kannada, Malayalam, Odia, Punjabi, Assamese are a few to name. Hindi is the national language of India and the primary language of 30% people of India (G. Cheney, Ruzzi, & Muralidharan, 2005). Hindi and English are the two most used languages in India (Pandharipande, 2002). Languages play an important role in learner's education at various levels. The first choice of medium of instructions (MoI) in India is mother tongue or regional language at school level. Regional languages are not only the MoI but also taught as a subject at the primary and secondary level of education in many schools in India.

State boards, CBSE board, ICSE board provide primary and secondary education in India (G. R. Cheney, Ruzzi, & Muralidharan, 2005). Boards are free to determine the languages in the curriculum for schools within the national curriculum outline.

CBSE and ICSE board use English as MoI in K-12 education while state boards use local language as the primary MoI and optionally allow students to choose English as MoI. Private schools, affiliated to state boards where regional language is Hindi, teach English as a second language (ESL) in primary and secondary level. While in other states where the local language is not Hindi, Hindi is taught as a second language and English as a third language. As we can see from Table 1.1, only 6.57% schools use English as the MoI in secondary education in India (Mitra, 2010). In English medium schools, all subjects except regional language and Hindi are taught with English as MoI. This way English medium students not only learn the content in English but also learn English language as a subject.

Table 1.1 Percentage of schools that teach English in India (Mitra, 2010)

	Primary (Classes 1 to 4/5)	**Middle (Classes 4/5 to 8)**	**Secondary (Classes 9 to 10)**
English as a first language	2.91%	4.25%	6.57%
English as a second language	21.65%	55.05%	54.12%
English as a third language	6.58%	38.02%	35.79%
Total for English	30.40%	97.32%	96.48%

After secondary education, many students pursue professional courses like medical, engineering or law as these are considered prestigious career options in India. The medium of instruction in all professional courses in India is English. State technical universities and deemed universities provide Engineering Education in India. Students have to qualify the entrance exam to take admission in the desired course. Various technical universities conduct these entrance examinations at the state or national level. The question paper for entrance examinations is in both English and Hindi medium. After qualifying the examination, students study in colleges affiliated to one of these universities.

Despite the fact that students are allowed to attempt entrance examination in Hindi and other regional languages (G. Cheney et al., 2005), all technical universities in India use English as MoI. Hence a large number of students who study English only as a second language (ESL) at the secondary level have to adapt to English MoI for their undergraduate engineering education. These students, referred to as vernacular medium students, face difficulty in studying in English MoI.

Vernacular medium student: In this report we use term “vernacular medium student” for the learners who are proficient in one language (Hindi or any other local language) and have little knowledge about the second language (mostly English). The Students we are targeting are those who are familiar with two or more languages, but they are more fluent in the primary language and are less fluent in the secondary language (English).

Who is not a vernacular medium student: A student who is either proficient in both languages or has no knowledge about secondary language is not considered as a vernacular medium student. A learner is assumed to be proficient in a language if his / her listening, speaking, writing and reading skills are very good in that language.

Content and language integrated learning (CLIL) is an approach where language is not taught as a subject, but subject contents are taught in that language (Wannagat, 2007). This way student not only learns the content but also learns the language. The education programs in CBSE / ICSE or English medium schools can be considered as CLIL programs (Dalton—Puffer, Nikula, & Smit, 2010). A professional course can also be considered as CLIL environment as students learn the content in English and simultaneously attain a certain level of competence in English during the course. English medium students have already learned in CLIL environment and face no difficulty in acquiring English medium instructions for various subjects. On the other hand, vernacular medium students find it difficult to understand the English medium instructions in a CLIL classroom. In a study conducted on students' academic performance, authors found that English MoI is one of the variables that highly influences the learning of a vernacular medium student and forces him / her to perform poorly (Bhardwaj & Pal, 2012). In his book (Chaudron, 1988) author states that a learner learning through a language other than the primary language faces problems because his / her task becomes threefold, as he / she has to-

1. Make sense of the instructional tasks presented in the second language.
2. Attain linguistic competence that is required for effective learning to take place.
3. Master the content as well.

In this thesis, we address some problems faced by vernacular medium students in a CLIL environment and suggest solutions for the same.

1.1.Problem Context

Engineering is a professional course and students are expected to be eligible to work in industry after the completion of their undergraduate program. Knowledge of English is one of the major requirements of the industry. If we continue teaching vernacular medium students in their primary language, they will find it difficult to develop competency in English. If we start teaching them in English medium of instructions (MoI) then sudden change in MoI will affect their performance. We need to find a solution to scaffold a vernacular medium student in such a way that one can make sense of the instructional task and simultaneously develop competency in English. These match with the two goals of bilingual education namely, students will be able to understand the concepts better and learners will be more proficient in the second language (McConnell, 1980).

1.1.1. Limitations of practical context

There are some limitations of practical context that need to be considered while developing a solution to problems of vernacular medium students. These limitations are limited time, assessment in English, English major classroom and non-availability of primary language learning material. Details of each limitation are given below:

1.1.1.1. Limited Time

Engineering is a professional course of four year duration, divided into eight semesters. Most universities in India have six subjects per semester in the first, second and third year and five subjects per semester in the fourth year of this course. Students remain extremely busy in completing the assignments, preparing for unit-tests and other additional academic activities throughout the semester. Engineering college timing is around 7 to 8 hours, and 75% attendance is mandatory. Hence students learn in a very busy schedule, leaving very little time to provide scaffold outside the classroom. Based on these facts we can say that solutions should be effective in comparatively lesser time.

1.1.1.2. Assessment in English language

In engineering education assessment is divided into two categories internal and external. Students need to pass in internal examination and external examination separately to pass in a subject. The external examination is a paper-pen based test to be answered in English medium. The internal examination is further divided into 2 unit-tests and number of assignments. Internal assessments are conducted at the college level and known as internal examination. University conducts an external examination at the end of each semester. Medium of assessment in both the examinations is English language. Thus if a student does not gain competency in writing and reading English, he/she may fail in the examination and may not be able to proceed to succeeding semesters. Hence the solution should help the student in gaining competency in English as well as educational content.

1.1.1.3. English major classroom

In engineering courses, the number of vernacular medium students is lower than that of English medium students (Ravi Pathiyil Shankar, y Mishra Pranaya, & Archana Saha, 2005). This low number of vernacular students creates affective problems for them. It is reported that peers laugh at them when they try to communicate in English language (Probyn, 2001). This behavior of peers lowers their confidence and students hesitate to ask questions or give answers to the teacher's questions thus stopping them to actively participate in classroom discussions. It is also seen that students can understand what is being asked, but they cannot express themselves in English and do not answer (Probyn, 2001). The solution should either reduce the affective problem of a student in the classroom or suggest an environment where affective problems do not exist.

1.1.1.4. Non-availability of primary language learning material

All affiliated colleges follow the same curriculum decided by the university. University recommends several textbooks for each subject. These textbooks are available only in English. Most of the times recommended textbooks are written by foreign authors and English language used in those books are of slightly higher level (Fennema-Bloom, 2009). Very few textbooks are available in the local languages. Even online course material and another study material are not available in the primary languages. Hence the solution should either create the material in primary language or teach the student in such a way as to make them comprehend the content presented in English.

1.2. Problem Statement

One of the important objectives of computer science education is to develop fundamental competency in the area of computer programming (Joint Task Force on Computing Curricula & Society, 2013). Knowledge of programming is so important that almost all computer science programs include a programming subject in their curriculum. This important subject is widely reported as being challenging for novices, especially in the earlier stage of learning (Shuhidan, Hamilton, & D'Souza, 2010). Students have significant difficulty in acquiring programming skills, as evidenced by their low success rate in the university exams (Mitra, 2010; Tollefson & Tsui, 2003).

Vernacular medium students find it more difficult to gain programming competency in English MoI. Thus, the central research issue in this thesis is to design an intervention to scaffold vernacular students within the limitations of practical context and achieve the goals of bilingual education. The main research question of this thesis is:

"How to scaffold a vernacular medium student within the limitations of practical context to achieve the goals of bilingual education?"

1.3.Personal motivation for this work

Hindi is my mother tongue. It is the medium to communication in my day to day life. I completed primary and secondary educations in a vernacular medium school where the MoI was Hindi for all subjects including English language. My school was affiliated to the state board of Uttar Pradesh, a state in north India. The Uttar Pradesh state board of education is also referred to as UP Board. Textbooks of UP board in high school and intermediate level include equivalent English words written in bracket along with each subject-specific terms of Hindi. While studying in school, I failed to understand the reason for learning all those unfamiliar English terms. Therefore, I never paid much attention to them like many of my classmates.

After completion of intermediate examination, I joined a coaching institute in Agra (my home town) to appear for engineering entrance exam which was to be conducted in English only. All teachers in coaching institutes were using English MoI to teach mathematics, physics and chemistry. This was my first experience of learning in an environment where the medium of instruction was completely in English.

On my first day in coaching class, I tried my level best to understand the subject, but this new language (English) to which I had never paid attention before made it difficult for me to understand anything the teachers were teaching. Next day when class began, I requested my chemistry teacher to teach in Hindi. He refused to do so by saying that the exams were to be attempted in English, and I was the only one who was having such problem. There were few students from Hindi medium in the class, but they were not complaining about English MoI. When I requested again, the instructor said that he can’t speak in the class in Hindi, but I could stop him to ask the meaning of the sentence that I didn’t understand.

I started focusing on what was being taught in the class. I realized that I was able to understand the meaning of the general English sentences, but wasn’t able to understand subject-specific terms, and that was why I was not able to understand the subject.

In the next chemistry class, I interrupted the teacher when he was talking about *alkaline earth metal* while pointing towards the periodic table. I asked him for the meaning of *alkaline earth metal* in Hindi. As I requested for it, I heard a loud sound of laughter from my classmates. He said with a smile that he was not knowing the equivalent term for *alkaline earth metal* in Hindi. I requested him to show *alkaline earth metal* in the periodic table so that I can tell its equivalent word in Hindi. When he pointed to the periodic table, I said that it is called Kṣārīya mṛdā dhātu (क्षारीय मृदा धातु) in Hindi. I again heard the laughter of peers in the class.

In the physics class, I was not able to understand the meaning of *refractive index*. I requested the teacher for its equivalent term in Hindi. He too did not know the answer and hence he requested my classmates to answer my query. No one in the class was able to answer it and to my surprise nobody even raised the question though the class consisted of good number of vernacular medium students. I did not understand anything in that class too.

At the end of the day, four of my classmates shouted at me with anger and said that they felt ashamed because of me. When I asked for the reason, they said that they also did not understand anything in the class but never asked a teacher to translate technical terms for them. This was because of the fear that the English medium students might think that the Hindi medium students were stupid and might make fun of them. I could not understand as to why one should get demoralized just because one cannot understand English, even though one knows the subject well in the primary language.

After that incident, I started memorizing the English meaning of subject specific words, but I did not stop interrupting teachers in the class whenever I found myself unable to comprehend. My intention was to make them understand that if admission is given to Hindi medium students then their needs are to be catered too.

One of the major concerns at that time was how to relate subject specific terms which were taught in English. I never heard these terms before. For example, refractive index is called 'apvartanaank' (अपवर्तनांक) in Hindi. Whenever teacher used only English, I got frustrated because I was unable to understand anything.

When I joined engineering college, MoI was English. I was again unable to understand what was being taught. At the intermediate level, I scored well in Physics and Chemistry, but I failed miserably at the undergraduate level because I was unable to understand English. That butchered my confidence, and I contemplated at one stage of even leaving the undergraduate program.

While pursuing engineering, I always felt the lack of subject textbooks written in Hindi or teachers who can explain topics in Hindi. In order to resolve this problem, I started using English-Hindi dictionary but very soon I realized that Hindi did not have all the necessary terminology for the technical terms which made it more difficult for me to understand the concepts. After that, I started using the English-English dictionary not only for the subject-specific terms but also for general English terms. I re-wrote the meaning of complex English words and sentences in simple English and annotated the textbooks. That considerably helped me to understand the subject and write in the examinations.

1.4.Solution Overview

In recent years, the affordances of information and communication technologies (ICT) have opened several possibilities to design and develop the learning material without the knowledge of programming. Availability of smartphones has opened new ways to provide access to the learning material to the students in the classroom and the students will have the freedom of learning the subject with their own pace.

Educational videos are currently being used all over the world. The price of hardware required to create educational videos has come down in recent years, and various proprietary and open-source software are available for this purpose. Technology that is being used to create educational videos is now affordable to most of the teachers, colleges or universities. Subject Matter Experts (SME) can create effective video tutorials with the proper training of very few days.

Now a days, almost every student owns a smartphone that is capable of playing videos in higher resolution and browsing the learning material available on internet or intranet. These smartphones are equipped with Wi-Fi and Bluetooth which facilitate easy sharing of the learning material within the classroom. It was not possible to provide self-paced learning material in a general classroom setting but with the use of technology different material can be delivered to different students not only in an online environment but also in the classroom setting.

Along with these lines, to address the main research question of this thesis, we developed various interventions to teach computer programming to vernacular medium students. These interventions were designed to provide language-based scaffolds and cognitive scaffolds. Cognitive load refers to the amount of mental effort made to comprehend the learning material. Comprehending the learning material presented in a secondary language increases the cognitive load of the vernacular medium student as one needs to translate the presented material before comprehending it. Cognitive load of vernacular medium student can be reduced by either using a language that reduces the need for translation or presenting it in a way that reduces the mental efforts to comprehend it. Language based scaffolds are the support that reduces the need for translation of the learning material to comprehend it. Cognitive scaffolds are the strategies to reduce the cognitive load of a vernacular medium student.

The interventions were developed using backward design approach to instructional design. In the backward design approach, expected outcomes or desired results of the learning process are defined first, then acceptable levels of evidence that support the outcomes are determined by planning the assessments and finally instructional strategies are aligned to achieve these outcomes (Richards, 2013; Wiggins & McTighe, 2001). This led to the following phases of research (Figure 1.1):

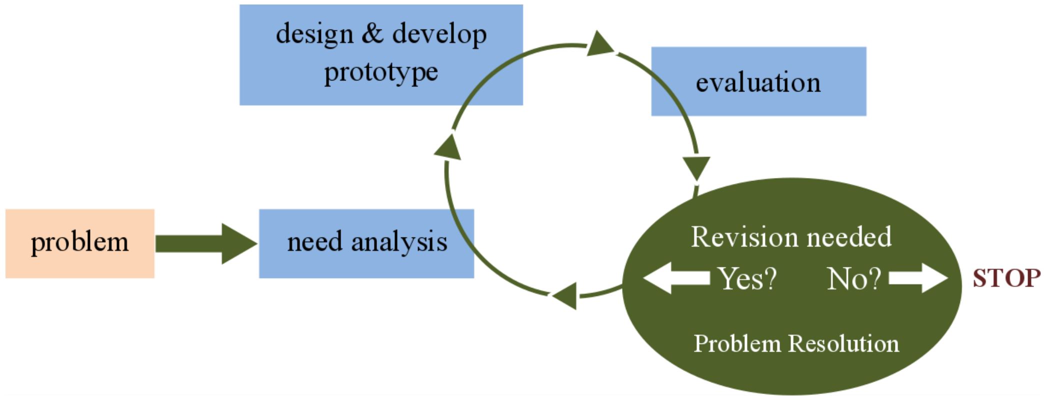


Figure 1.1 Four phases of a research cycle

- Need analysis: Identification of problems and their possible solutions.
- Design and develop prototype: Selection or creation of the learning material and/or instructional strategy.
- Evaluation: Evaluation of the prototype regarding the performance improvement.
- Problem resolution: Based on learning happened during the whole research cycle how to move to next research cycle.

Instructional strategies useful for vernacular medium students were identified by reviewing the literature in each research cycle. Learning material was either selected or designed based on these instructional strategies. Literature review suggests that vernacular medium student needs support at cognitive, language and affective aspects in a CLIL program. In a CLIL program, the educational content is delivered in a way that helps learners to develop English competency and learn the content. Cognitive support is provided by following cognitive load theory in development and presentation of educational content. Visualization guidelines to teach various educational content and multimedia principles to present educational content are used to provide cognitive scaffolds to learners to reduce their cognitive load. Language based scaffolding was developed based on the theory of bilingualism and cognitive load theory. Students receive affective scaffolds because of the self-paced learning environment.

To provide the correct sequence of learning material aligned with the correct learning objectives we selected ACM CS curricula for computer programming (Joint Task Force on Computing Curricula & Society, 2013) and selected few topics to teach the same. We applied visualization guidelines (Ruth C Clark, 2011) to teach various educational content types with the pedagogy of computer science education to develop / select learning material. The intervention was evaluated using the research methodology described in next section. Based on the result in each cycle, learning material was redesigned / selected and tested again for the next cycle.

1.5.Methodology

Vernacular medium learners can have any combination of primary language and secondary language. The research process for developing interventions for vernacular medium students is Education Design Research (EDR) methodology (Plomp & Tjeerd, 2013). EDR is used in design and development of intervention as a solution to the complex educational problem as well as advance knowledge of researchers about the characteristics of intervention and design and development process of intervention. EDR has four phases as problem analysis, design of prototype, evaluation and problem resolution. The phases are sequentially executed, and the outcome of each phase triggers the next phase. Each phase leads to different research questions which can be approached using qualitative and/or quantitative research methods requiring a different set of data sources. Figure 1.1 represents all four phase of education design research.

The first phase is 'needs analysis' phase in which problems of previous research cycles and possibilities to scaffold vernacular medium students were identified. In the next phase i.e. 'design and develop prototype' phase, the prototype to scaffold vernacular medium students is conceptualized and learning material was either developed or selected if matched with the properties of the prototype. Prototypes in each research cycle are designed by literature review and findings of the previous research cycle. The third phase is 'evaluation of prototype'. This phase is approached using quantitative/qualitative analysis to measure expected or actual effectiveness of the prototype. The findings from the quantitative method are explained using analysis of post-test scores of students and finding from the qualitative method are explained using text-analysis of interview data collected from students and/or teachers. The final phase is problem resolution phase where learning and findings of the whole research cycle are reported, and decisions are made on whether to move onto next research cycle or not.

We carried five research cycles to develop guidelines to create an effective solution to teach programming to vernacular medium students. We started with classroom recorded videos in first research cycle and found that classroom lectures were not effective and needed to be designed carefully for learning. In the second research cycle, we selected video tutorials that were developed especially for video-based learning and conducted a qualitative study with few students and teachers. We found that these videos needed improvement in the systematic design of educational content and presentation style. Also, these videos needed improvement in handling vocabulary to teach vernacular medium students. In third research cycle, we created video tutorials by following visualization guidelines to teach educational content, presented it by following multimedia principles. Vocabulary in these videos was used based on the findings from the literature review. We used qualitative research method to measure the effectiveness of the videos. Qualitative research in this research cycle is carried out with students to measure the actual effectiveness of the prototype. We did not find any shortcoming in educational content and its presentation. Few shortcomings were identified in the use of language and needed improvement at the language level. Fourth research cycle presents a quantitative study, where we implemented all findings of previous research cycles and interventions was provided in a classroom environment. We found some problems in the classroom environment because of which it was not suitable to teach vernacular medium students. In fifth research cycle, we used video based self-paced study environment in a quantitative study. The content development and presentation was based on multimedia and instructions design principles to provide cognitive scaffolds. Language based scaffoldings were designed by bilingual theory and findings of all previous research cycles. We found that vernacular medium students performed significantly better as compared to their performance in the previous research cycle. The performance of vernacular medium students in fifth research cycle was not only satisfactory but also completing the goals of bilingual education within the limitations of practical context.

1.6. Scope of the thesis

The scope is limited to first year of undergraduate students as language based scaffold is required only in the first year (Yang, 2015).

1.6.1. Scope of languages

In this thesis, our interventions are designed by considering Hindi as primary language and English as a secondary language, which is the case for most of the North-Indian engineering colleges. In most of the Indian context, the secondary language will remain English while primary language will change from state to state. Vernacular medium students learn English as a subject in K-12 and develop some competency in the English language.

1.6.2. Scope of content

We developed learning material and interventions to teach computer programming using *C programming language* within the context of computer science course. All first year engineering undergraduate programs in all universities teach this course. All students who pursue engineering course have to complete this course irrespective of their choice of engineering branch. This course is a foundation course in information technology and computer science subjects. We have selected topics from the course which have been shown to be important in computer programming. The major topics selected are conditional statements, functions, and recursion. In addition to this variable, data types, arithmetic and logical operators are also considered so that students can learn the major topics.

1.7. Contributions of the thesis

The major contribution of this thesis is to develop a framework to teach programming to vernacular medium students in English only MoI or bilingual MoI. Major components of this framework are the language based scaffolds, cognitive scaffolds, and appropriate learning environment. These contributions are listed below:

- Language based scaffolds are identified, implemented and tested to teach vernacular medium students in a secondary language.
- Visualization guidelines to teach various educational content are selected, implemented and tested to reduce the intrinsic cognitive load of vernacular medium students.
- Multimedia principles are selected, implemented and tested that help in reducing the extrinsic cognitive load of vernacular medium students.

- Appropriate teaching-learning environment is identified and tested in which cognitive, and language based scaffolds are effective for vernacular medium students.
- Based on these findings we created and tested scaffolding framework to teach vernacular medium students. This scaffolding framework can be used by researchers and educators to develop educational screencasts to teach programming languages in a CLIL program.

During the development of the prototype, we developed learning material like slides, source code, and screencasts. These learning materials are tested to teach Hindi medium students in English MoI. Teachers can use this material to teach vernacular medium students and researchers can use to create new interventions for them.

The minor contributions of this thesis are as under:

- Screencasts in English as well as in Hindi are developed to teach C programming language that covers major topics of programming language. Running time of videos was 3 hours 10 minute in one language i.e. total 6 hours 20 minutes training screencasts were recorded for two languages.
- Sixteen source codes were written in C programming language. Slides were created and validated according to multimedia principles and ACM CS curricula.
- All learning resources created for research in this thesis are available online[1] under creative commons license.

1.8. Organization of the Thesis

This thesis is organized in ten chapters. Chapter 1 is the introduction. In Chapter 2, we review the literature in the 'problem space' of the thesis, i.e. what problems do vernacular medium students face in acquiring programming knowledge due to English MoI. In the 'solution space' we review the literature to know how teachers are teaching vernacular medium students and what the success rate was. We also analyze the practical context to be considered before designing the solution. Chapter 2 thus leads to the main RQ of the thesis: *how to teach programming to vernacular medium students to improve their performance in an undergraduate program where MoI is English*? Chapter 3 describes the overall research methodology used in the thesis to answer the RQs. Research approach described is EDR with four phases. Each phase is described using research methodology. This chapter not only

[1] http://www.et.iitb.ac.in/sfvms

describes the method but also explains the relevance of chosen RM to solve the corresponding RQ. The research method for each phase is described in detail with diagrams and steps. After describing the overall structure of this thesis, the detailed implementation of methodology with findings are described in chapters 4, 5, 6, 7 and 8.

Chapter 9 presents all scaffolds identified during the research work of this thesis and scaffolding framework to teach vernacular medium students in English only MoI or bilingual MoI. Chapter 10 provides the discussion of the results and findings of all research cycles. It also presents generalizability, limitations, and scope for future work.

Chapter 2

Literature Review

In chapter 1, we presented an overview and motivation of the research of this thesis. In chapter 2, we present the literature review conducted during the various phases of the research cycles. Section 2.1 presents the problems of vernacular medium students reported in the literature. Section 2.2 presents a qualitative study conducted to identify the problems of vernacular medium students in the Indian context. In Section 2.3 we present a categorization of the problems of vernacular medium students. Section 2.4 presents the problems that arise in general classroom settings. Solution space (Section 2.5) presents the corresponding possible solutions from literature.

2.1.Problems of vernacular medium students

The research shows that the problems faced by vernacular medium students fall into four main categories. These problems make it difficult for a vernacular medium student to comprehend the learning material presented in English MoI.

- **Non-fluency in secondary language:** Vernacular medium students perform poorly in academics because of non-fluency in secondary languages (Probyn, 2001). English medium students more strongly agreed that "the subject has created a knowledge base which will help them to choose the subject in future practice" compared to vernacular medium students (Ravi Pathiyil Shankar et al., 2005). Teachers reported that students do not participate in discussions in the classroom because they had problems in communicating what they did know; this contributes to high failure rate (Probyn, 2001).

- **Non-availability of subject-specific vocabulary in local language:** Limitations of subject specific words in the primary language is another major problem of vernacular medium students. Learners try to translate the secondary language words in their primary language for better understanding and face difficulty when their primary language did not have the necessary subject terminology (Probyn, 2001). Because of poor English proficiency students do not know the meaning of the English roots of some subject-specific terms and are unable to comprehend them (Probyn, 2001).

- **Affective problems:** For vernacular medium students, English MoI is a burden, and frustrating. Teachers who taught such students reported that they were feeling as they are dragging, hooking, and pulling vernacular medium students in the class (Probyn, 2001). In engineering courses, the number of vernacular medium students is lower than that of English medium students (Ravi Pathiyil Shankar et al., 2005). It has been reported that peers laugh at one another (Probyn, 2001). This behavior of peers lowers their confidence, and they feel demotivated. Moses found that students in a secondary language only classroom were unable to understand what is taught in the classroom. This makes them academically poor and reduces their confidence and self-determination power (Moses, 2000).

- **Non-participation in learning activities:** Students hesitate to ask questions, give answers to the teacher's questions and do not actively participate in classroom discussions. It is also seen that students can understand the questions being asked, but cannot express themselves in English and hence do not answer (Probyn, 2001).

2.2. Confirming findings of literature in Indian context

We confirmed the findings of literature, presented in Section 2.1, in Indian context by conducting a qualitative study. The research question for this study is: *What problems do vernacular medium students face while studying in the classroom and during self-study because of English as MoI?*

Twelve students were selected as the sample, eight males and four females. We interviewed all students separately. We used purposive sampling to select the students. We selected only those vernacular medium students who were failed in more than four subjects in first year engineering examinations. We selected students from three different colleges of north India.

Research Design

The study was designed using the analytic induction method. After selecting an appropriate sample for the study, each student was interviewed regarding his / her experiences with English as MoI. The data was classified and categorized using the content analysis method

(Krippendorff, 2012). After analyzing the transcripts of the interviews, the conclusions emerged naturally from the data.

Data Collection

The interview was recorded in digital audio format and later transcribed. These transcriptions are then analyzed. The interview was conducted in Hindi and students were free to answer the questions in their choice of language. All students answered in Hindi.

Instrumentation

To ensure the reliability of the interview questions, the questions were developed from my own experiences as a vernacular medium student and from the problems reported in the literature. The questions were the only source of data collection. They were open-ended to ensure interview validity. The interview questions are as under:

Interview questions

1. Why did you fail in engineering examinations?
2. In how many subjects did you fail?
3. Name the subjects in which you failed.
4. Why did you fail in the subjects that you have already studied in K-12, like science, physics, mathematics and chemistry.
5. What problems did you face in the classroom?
    a. Did you try to solve these problems, if yes how?
    b. Did you ask the teacher to teach in Hindi?
        i. If no, why?
        ii. If yes, did the teacher accept your request?
    c. What was the ratio of vernacular medium students in your classroom?
    d. What affective problems did you face in the classroom?
        i. Did you hesitate to ask questions in class because of language barrier?
6. How were you doing self-study?
    a. Videos or books?
        i. What books do you use for study, standard or non-standard and why?
        ii. Do you use videos for study?
            1. If yes, why?

2. If no, why?

b. Did you use any dictionary? English-Hindi or English-English?

i. How did you deal with subject specific words?

7. Now you have completed 1st year, do you still face problems in English MoI?
8. What will be your suggestion to other vernacular medium students studying in the first year to overcome the language barrier?

Analysis

To answer the research question, we transcribed and analyzed student interviews using content analysis. The responses were initially coded along the categories of the four questions regarding acceptance of English problem, classroom problem because of English MoI and possible solutions, self-study problem because of English MoI and possible solutions, affective problem because of English MoI. However one category, time constraint, emerged from students responses. Within each category we initially coded students' description of their problems and possible solutions based on various factors. The codes describing non-unique/overlapping behaviors were then merged. The final list of codes along with their category is given in Table 2.1.

Table 2.1 Code and categories of student's problems and possible solutions

Category	Code
Acceptance of English MoI as a problem	• Accept English listening problem • Accept English reading problem • Accept English writing problem • Accept English speaking problem
Problems in classroom because of English MoI	• Problem because of teachers • Problem because of peers • Problem because of inferiority complex
Possible solutions applicable in classroom	• Solutions that can be applied by teachers • Solutions that can be applied by peers • Solutions that can help in reducing inferiority complex
Problems in self-study because of English MoI	• Choice of learning material • Problems related to books • Problems related to videos • Problems with general English words • Problems with subject specific words
Possible solutions applicable to self-study	• Solutions related to types of learning material • Solutions related to books • Solutions related to videos • Solutions to general English words • Solutions to subject specific words
Affective problems because of English MoI	• Activities that leads to affective problems • Effect of affective problems
Time constraint	• Evidence of time constraints • Problems because of time constraints • Solutions if there are no time constraints

Results

The results of the content analysis, namely the problems and their solutions observed from students' interview are shown in Table 2.1. From the results, we note that students were facing problems in both classroom and self-study environments. Students were facing difficulties in listening, speaking, writing and reading when learning material is presented in English MoI. The approach used by students to solve the problems were limited because of the time constraints imposed by the extensive syllabus. Students were not only facing difficulties in comprehending learning material but also facing the affective problems. Affective problems were limited to classroom context only and creating issues in participation. Self-study environment was free from affective problems.

The solutions followed by the students to solve their problems are different for classroom and self-study environment. The problems because of English MoI in the classroom are dependent on instructors and peers. Teachers' use of English MoI for oral explanations was the barrier to learning in the classroom. Peers behavior in the classroom was creating the inferiority complex in vernacular medium students. The inferiority complex was then leading to limited or no participation in classroom activities like asking a question, participating in classroom discussion etc. Students believed that use of Hindi MoI for oral explanations would help in comprehending learning material. Teacher's limited knowledge of Hindi vocabulary for subject specific words was another problem reported by students. Teacher's habit of delivering the lecture in English MoI and non-availability of Hindi meaning of subject specific words were two factors stopping teachers to give a lecture in Hindi.

All students accepted that self-study was the only way to pass the examinations because of the limitations of classroom environment explained above. The self-study was allowing them to receive and comprehend learning content at their pace. Books and video tutorials were two possible choice for self-study for each student.

Video tutorial was the first choice for self-study for each vernacular student we interviewed, as learning from videos consumes less time compared to books. Non-availability of video tutorials in Hindi MoI was one of the major problems in adapting only video based self-study approach. Video tutorials using English as MoI were recorded by foreign authors in the foreign accent that makes it impossible to comprehend the learning content even in self-pace mode. Students mentioned that videos recorded by Indian lecturers are not available in Hindi, but they can understand them because of Indian accent used in the verbal explanation. Students were able to comprehend the learning content from videos recorded in English MoI in Indian accent after watching them several times. Students didn't find video tutorials that directly mapped with their syllabus. Searching appropriate video tutorials that mapped with the syllabus and available either in Hindi MoI or English MoI with Indian accent is a difficult and time-consuming process. These problems with video tutorials lead them to use their second choice for self-study, books in the first place.

Books were the second choice for self-study by vernacular medium students. Students started with standard books, recommended in university syllabus. Foreign authors generally write these books and use complex general English words. The choice of complex English words and long sentences was the main problem in studying with the recommended books.

Standard books do not cover complete syllabus, four or five standard books cover the syllabus that makes the situation worse for students. Soon after realizing that reading from these books is difficult, students jumped to the books written by Indian authors that covered complete syllabus for a subject in one book.

Books are using general English words and subject-specific words. Indian author's choice of words in the book is simple compared to foreign authors. Still there were many words those were unknown to vernacular medium students. Students were always using dictionary with them to find out the meaning of all the words. Students reported using English-Hindi dictionary in the beginning for self-study. Very soon, they realized that English-Hindi dictionary does not have meaning for all words. Sometimes the Hindi meaning is more complex than English synonym of the word. Seven out of twelve students started using English-English dictionary after this realization. Other five students accepted the fact that sometimes English synonyms is easier to understand than its Hindi translation. The reason for not using English-English dictionary was affective, as they made their mind to drop-out from the course. It was difficult for vernacular medium students to memorize the Hindi meaning of all subject specific words and using them while reading from books. These problems with textbooks were making their learning slow as they have to jump from textbook to dictionary many times during the study.

As a solution to the problems in self-study, students suggested that video tutorials mapped with their curriculum and recorded in Hindi MoI will be their first preference. Along with the videos, books should be provided in English but using simpler general English words and Hindi meaning of subject specific words should be given with the word. This will save their time of looking at the dictionary for meaning.

Students reported the loss of confidence after entering into the program because of English MoI. Vernacular medium students are considered as low achievers by the teachers and management; this lowers their confidence, and they start thinking themselves as low achievers even though they have got good marks in K-12. Vernacular medium students were unable to make English sentences because of low English proficiency. This limitation in sentence construction was stopping them from asking the question or participate in the discussion, as they were worried about peers will laugh at them after listening to the wrong use of English.

Time constraints were stopping vernacular medium students from joining a classroom or external tutor to learn the content in Hindi. Time constraints were also creating some affective problems as students believed that self-study can help in comprehending the content but also felt that they can't do this before final examinations. This thought was demotivating them and stopped them from continuing with the education program and eventually leaded to drop out from the course. Five out of twelve students we interviewed dropped the course few month later after the interview. "I need a teacher to understand the learning material that is written in English in textbooks. If these books are in Hindi, I won't need them" – as one student quoted.

Table 2.2 Problems of vernacular medium students

Problems of vernacular medium students	**Personal Experience**	**Literature**	**students**
Difficult to understand the verbal explanation in English MoI.	Y	Y	Y
Non-availability of learning material in Hindi is a problem during self-study	Y	N	Y
English major classroom creates affective problem.	Y	N	Y
Lower English competency and affective problems are the cause of non-participation in the classroom.	Y	Y	Y
Use of complex general English terms in self-study material was making it difficult to comprehend the material in limited time.	Y	N	Y
Hindi meaning of some general English words is difficult than English synonyms of the words.	Y	N	Y
Limited Hindi vocabulary for subject-specific term was a problem	Y	Y	Y

Table 2.3 Possible solutions of the problems of vernacular medium students

Solutions for vernacular medium students reported in literature	**My experience**	**Literature**	**Students**
Using Hindi MoI in classroom for verbal explanation	Y		Y
Self-paced is preferable over classroom as it gives a chance to comprehend the material at own pace.	Y		Y
Use of simple general English words will be helpful in self-paced environment	Y		Y
Reducing the chance to use dictionary will reduce the time to comprehend the learning material.	Y		Y
Educational videos are better than books for self-study if available in Hindi MoI.	Y		Y

2.3. Categorization of the problems of vernacular medium students

Based on the literature review conducted to identify the cause of difficulties of vernacular medium students (Section 2.1) and qualitative study (Section 2.2), we categorize the problems of vernacular medium students in three categories 1) cognitive, 2) language-based and 3) affective. Cognitive problems affect the cognitive load of vernacular medium learners, language-based problems make it difficult to comprehend the learning material and affective problems lead to loss of confidence and non-participation in learning activities. These three category of problems are discussed in this section.

2.3.1. Cognitive problems

According to John Sweller et al, cognitive load of working memory increases while learning new content (John Sweller & Chandler, 1991; John Sweller, 1994). This load is classified into two categories, intrinsic and extrinsic. Intrinsic cognitive load depends on the content being presented and extrinsic load depends on the way content is being presented. The intrinsic cognitive load depends on the elements interactivity and can be reduced by reducing the number of elements in content. The extrinsic cognitive load can be reduced by changing the instructional strategy.

In instructions where only secondary language is used, it becomes one of the factors that increases extrinsic cognitive load (Mehisto, 2012). Even if we identify the correct strategy to reduce extrinsic cognitive load, Hindi medium students will always be bearing more extrinsic cognitive overload as compared to English medium students who are learning in English MoI.

2.3.2. Language based problems

Vernacular medium students receive instructions in primary language in K-12. Even in English language class, the language of MoI, classroom management and peer interaction is primary language. They have no exposure to receiving English MoI in a CLIL environment. Their English listening skills are not developed enough to match the pace of instruction delivery of the teacher. Their general and subject-specific English vocabulary is very poor. As soon as they encounter few unknown words they lose their concentration, though they are able to understand English as MoI. Many technical subjects have limited local language vocabulary, hence students remain unable to find the equivalent meaning in local languages for technical terms and feel helpless. Standard textbooks are not available in the local languages and most of the time are written by foreign authors. The sentence structure and choice of general English words do not match with the understanding of Hindi medium students and hence they always need some external help to interpret the matter given in these textbooks. This hampers their learning process and they need to memorize a long list of English words, which is a difficult and time consuming task (John Sweller, 1994).

2.3.3. Affective problems

Students in undergraduate programs come from various background. As we can see the heterogeneity of K-12 education in Table 1.1, an engineering classroom is a heterogeneous classroom which is a combination of students coming from local language medium as well as from English medium. Local language medium learners who have studied in ESL environment in K-12 are in the minority and few of them learn English as a third language. They are unable to match the pace of instructions being delivered in English and their cognitive load is more than that of English medium students. They are less fluent in English and as they try to ask questions in English, they are ridiculed at by their classmates. This lowers their confidence and they avoid asking questions and restrain themselves from actively participating in classroom activities.

2.4. Problems of general classroom environment

Literature reports that students in a traditional classroom environment are unable to concentrate after 20 minutes (Kalish & Middendorf A., 1995). If students miss something because of low levels of concentration they have no chance to hear it again.

Classroom environment has some distractions that can result in low concentration of learners. These distractions can be generated by students entering the class late, peers sitting next to each other and many other things (Simpson, 2006). Sometimes the distance from the lecturer and the whiteboard makes it difficult for the student to focus thereby creating distraction.

It is also been reported that students want to take notes of everything in the classroom environment so that they can read and understand it later. They keep themselves busy in taking notes and do not try to understand the topic in the classroom.

These distractions in a classroom environment result in poor performance of the students. These distractions make it more difficult for learners who are studying in a secondary language as they have to simultaneously understand the content and the language (John L. FaLconer J. Will Medlin, and Michael P. Holmberg, 2009).

2.5. Solution space

Vernacular medium students face problems in learning from English MoI. These problems are briefly described in Section 2.1 and confirmed in Section 2.2. We then categorize the problems of vernacular medium students in three categories cognitive, language based and affective. In order to solve their problem at cognitive, language-based and affective level we need to give support at all levels. This support is required only at the initial stage of use of English MoI as reported by (Yang, 2015). The temporary support provided to learners during the learning is known as scaffolding (Toomela & Valsiner, 2010).

In case of vernacular medium students a Zone of Proximal Development (ZPD) can be defined as the initial time when students join CLIL program in secondary language MoI. Before entering into the ZPD they cannot understand English MoI, however after crossing the ZPD they can understand English MoI without extra support. ZPD is the area where vernacular medium students require supports to comprehend the content presented in English. The ZPD for vernacular medium students joining CLIL programming is presented in Figure 2.1.

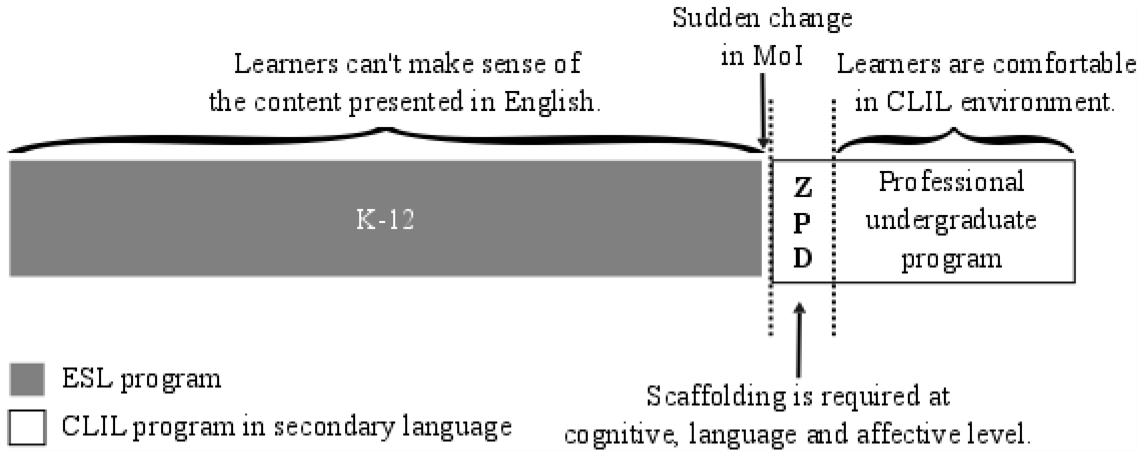


Figure 2.1 ZPD for vernacular medium students joining CLIL program

Figure 2.1 indicates the ZPD where a vernacular medium student needs help at cognitive, language-based and affective level. The student do not need support after he/she crosses the ZPD. Thus scaffolding can be provided only within the ZPD (Walqui, 2006).

Section 2.5.1 presents a brief survey of scaffolding techniques and how these can be implemented to support the learning of vernacular medium students.

2.5.1. Scaffolding

Scaffolding is the process of providing support or assistance to the learner to complete a task or achieve a goal which learner cannot do without the support (Wood, Bruner, & Ross, 1976). To provide scaffolding to learners, an instructor identifies the elements of instructions that are beyond the capacity of the learner and provides support for these elements. This scaffold (support) helps the learner to advance his/her learning by concentrating on only those elements which are within learner's capacity. Vygotsky defined ZPD as the area where learning takes place and learner needs support (Vygotsky, 1980). According to Vygotsky (Vygotsky, 1980) – "*The distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving with support*". A scaffold is a temporary framework, once the learner gains the competency to do the task without support, instructor withdraws it (Hammond, 2001; Toomela & Valsiner, 2010).

2.5.1.1. Types of scaffolding

Various types of scaffolding are defined by authors (Brush & Saye, 2002; Sercombe, 2003; Yau, 2011; Yelland & Masters, 2007). This section presents some of them.

Authors Beed et al define incidental and strategic scaffoldings (Beed, Hawkins, & Roller, 1991).

Incidental Scaffolding: This is a type of scaffolding that is provided unconsciously or unintentionally to the students. Although scaffolding exists, it is not strategically provided to the student. A classic example of this type of scaffolding is a child learning to speak in his/her mother tongue without any formal teaching. In this case, the environment of home and neighborhood act as scaffolding (Beed et al., 1991). Similarly a vernacular medium student's English proficiency increases in an undergraduate program where MoI and language of classroom management are English.

Strategic Scaffolding: Strategic scaffolding is a type of scaffolding that is consciously provided to learners by instructors. When a child is trying to walk, parents intentionally provide some kind of support and gradually withdraw it as the child learns to walk (Beed et al., 1991; Wood et al., 1976).

Brush and Saye conceptualized soft and hard scaffoldings for student-centric multimedia supported learning environments (Brush & Saye, 2002).

Soft scaffolding: They define soft-scaffolds as dynamic and situation-specific aids. Soft-scaffolds can be provided by continuously diagnosing the understanding of learner and providing timely support based on the students response. According to this definition, soft-scaffoldings can be provided by intelligent systems that respond to student's behavior.

Hard Scaffolding: hard scaffold is defined by Brush and Saye in (Brush & Saye, 2002) as static support that can be planned in advance based upon student's difficulties with a task. Hard scaffolds can be provided to learners only if we know where students typically face problem. This thesis explores the problems of vernacular medium students and provides hard-scaffolds in a multimedia supported learning environment.

Cognitive Scaffolding: Yelland and Masters coined the term cognitive scaffolding to denote the activities related to the development of conceptual and procedural understandings with the use of technique or device (Yelland & Masters, 2007). In this thesis we identified and tested several cognitive scaffolds to reduce the mental effort of students.

Technical scaffolding: Technical scaffolding is provided by the use of technical devices or techniques (Yelland & Masters, 2007). This scaffolding cannot be provided without the technical devices or techniques. In this approach to scaffolding, tutorials can be provided by computer-based knowledge base which may contain hyperlink text, audio, video, animation, simulation etc. Use of intelligent agent in some collaborative activity also comes under technical scaffolding. In this thesis we have developed several scaffolds that can be provided with the help of technology alone.

Affective scaffolding: Affective scaffolding is used to encourage students to indulge in higher levels of thinking. This scaffolding is achieved by providing the challenge to the student or by arousing his curiosity. The goal of this scaffolding technique is to motivate students and keep them engaged with the task while they are participating in various learning activities.

Black-box scaffolding: Hmelo and Guzdial have defined black box scaffolding as *"Black box scaffolding facilitates student performance (more than learning) but is not meant to fade during use of the environment"* (Hmelo & Guzdial, 1996). This definition may seem to conflict the original definition of scaffolding but it is not the case. It completely depends on the learning objective of a current topic or learner's current state. It performs a task in place of the students, usually because learning to perform that task is not the primary goal of the activity.

Glass-box scaffolding: Hmelo and Guzdial have further defined glass box scaffolding as *"Glass-box scaffolding facilitates performance and learning, but may fade during use of the environment"* (Hmelo & Guzdial, 1996). This is most commonly used type of scaffolding. Learners must know about the glass-box scaffolding during the use of the environment so that they try to internalize the concept or process that is currently being achieved with the help of scaffolding.

2.5.1.2. Level of Scaffolding

The level of scaffolding helps teachers to define the amount of support that needs to be provided at the current state of students understanding. This can be defined as low level and high-level scaffolding.

Low-level Scaffolding: Low-level scaffolding represents a type of scaffolding that needs to be provided to students with high prior knowledge with ill-structured or complex tasks.

High-level Scaffolding: High-level scaffolding represents the type of scaffolding that needs to be provided to students with low prior knowledge with simple or well-written problems.

Beed, Hawkins, and Roller (Beed et al., 1991) defines 5 levels of scaffolding. Gradual withdrawal of support can be seen in these levels of scaffolding. These levels are-

Level E: Teacher modeling. In this level teacher present everything in front of students with verbal explanation (Beed et al., 1991). For example while teaching flow chart; the teacher will first start by drawing various symbols that are used to create flowcharts. Choose a problem and identify various variables in the problem. Then make use of these variables making a flow chart to solve that problem. During these steps he keeps explaining all the details to students. In this thesis, we used teacher modeling as students are new to the topic, computer programming.

Level D: Inviting student performance. In this level of scaffolding teacher present everything with verbal explanation but also encourage students to participate in the activity. For example teacher will now choose another problem and identify variable in it and ask students why this is a variable. If students are unable to answer teacher will explain it again. Then he will choose another variable in the problem and ask students why this is a variable.

Level C: Cueing specific elements. In this level of scaffolding teacher guide student with verbal cues while solving the problem. These verbal cues are about the path required to solve the problem. For example teacher will give a problem to students and ask them to identify the variables in it. It is important to know that teacher will not ask students to make the flow chart. Once students identify the variables then teacher give him another task by cueing the specific element. In this case teacher will ask a student to initialize them by using appropriate flow chart symbol and so on.

Level B: Cueing specific strategies. This is defined in (Beed et al., 1991) as: *"The teacher gives verbal cues about general strategies the student might use."* In this step teacher will provide a hint to the student that what is the specific strategy you can use in this situation. For example by giving a programming problem teacher ask students to follow the steps of making a flow chart.

Level A: Providing general cues. This is the level of scaffolding where student works almost independently. The teacher provides the least support by asking a question about what will you do now? For example ask students to make a flowchart by giving them a programming problem.

2.5.1.3. Threats to scaffolding

Scaffolding can be provided within learners' zone of proximal development. So it is necessary for a teacher to find out various zone of proximal development and design scaffolds for that ZPD. Providing right scaffold in the right ZPD is a challenging task.

In summary, as Nada Dabbagh in (Dabbagh, 2003) states that "Scaffolding is all about providing the right amount of structure in a learning environment, keeping in mind that some learners may require little or no structure and others may require a lot of structure." Providing too much scaffolding could result in loss of motivation and interest in the subject. Low scaffolding could result in anxiety, frustration, and finally loss of motivation and attrition.

2.5.2. Teacher's practice of teaching vernacular medium students

This section presents the techniques used by teachers around the globe to solve the problems of vernacular medium students, and the theoretical background for these solutions. We notice that teacher is using primary language only instructions (Section 2.5.2.1), both primary and secondary language instructions (Section 2.5.2.2) and secondary language only instructions with support (Section 2.5.2.3). The support in secondary language only instructions are speak slow, repeated instructions, use of visual aids and others.

2.5.2.1. Use of primary language

Experiments for teaching using a combination of English and local language have been carried out for subjects like mathematics (Kim, Ferrini-Mundy, & Sfard, 2012), physics and chemistry (Venkatesan, Chandrasekaran, & Joseph, 2010). These studies show that there is a benefit in using local language for instruction. In (Kim et al., 2012), the authors conducted a comparative study on English and Korean medium students and found that Korean medium students have greater achievement in mathematics if taught in Korean. In (Venkatesan et al., 2010), the authors conducted an experiment in teaching physics to two groups of students and found that using the local language (Tamil) results in a significant increase in test-score after treatment. Teachers used the primary language to ask questions when learners didn't seem to understand. Teachers reported that they used primary language to maintain classroom discipline and management. When there is a new subject-specific word or new concept occurs teachers explained it in the primary language to scaffold vernacular medium students (Probyn, 2001).

The literature shows that use of primary language is useful for students. In this thesis we can't use primary-language-only instructions as we want the learner to gain competency in the subject as well as in English. Few ideas like using primary language to maintain classroom discipline and explaining subject-specific words in primary language can be adopted for the solution.

2.5.2.2. Use of both languages

CLIL (Content and Language Integrated Learning) programs suggest use of secondary language (English) in various aspects of teaching and learning. English is the first choice of medium of instructions (MoI) in educational institutions for professional undergraduate programs but teachers sometimes switch to local language instructions to scaffold content learning. This technique is known as translanguaging (García & Sylvan, 2011; Mazak & Herbas-Donoso, 2015), code-switching (Fennema-Bloom, 2009) and code-mixing (Berthele, 2012). Code-switching is the widely accepted term for the practice of switching medium of instructions between two languages based on the affective needs of the learners. Several benefits of code-switching are reported in the literature. One benefit of code-switching from secondary language to primary language is that it helps the learner to focus, clarify or reinforce lesson material that leads to content acquisition and makes the secondary language more accessible (Fennema-Bloom, 2009). It also reported helping at affective level by increasing the participation among the students (Fennema-Bloom, 2009).

Teachers use of code-switching falls under following categories, Instructional for content acquisition, reformulation, instructional for language acquisition, facilitation and habitual (Fennema-Bloom, 2009). Code-switching for content-acquisition depend on the targeted vocabulary, use of instructional material or setup of instructional activity. This type of code-switching is used when content instructions are provided with the help of two languages. Reformulation code-switching is used to repeat the instruction in other language based on the feedback from the learner. Instructions for language acquisition are used to increase language competency and not related to the development of content. Code-switching for facilitation is used for classroom management. Code-switching occurs because of the habit of the teacher to speak a word repeatedly for example "okay" or "you-know", known as habitual code-switching.

2.5.2.3. Use of secondary language with support

Teachers also reported to use simpler vocabulary, spoke more slowly, repeated and allowed a longer wait time for answering questions, drawing examples from students everyday lives, active learning and using visual aids to scaffold vernacular medium students (Probyn, 2001).

To support vernacular medium students Gujarat teacher's training text give following guidelines for the teachers.

- He may use the primary language to explain unfamiliar words when the explanation of those words in English is more difficult than the words themselves. For example, abstract nouns, ideas, etc.
- He may use the mother-tongue to explain abstract words, phrases, and idioms.
- He may use the mother-tongue in the classroom to test pupils' comprehension.
- He may use the mother-tongue to help pupils to learn to use the dictionary.
- He may use the mother-tongue when giving instructions to pupils.

From the literature survey reported in this section, it is clear that vernacular medium students need some kind of scaffolding. Researchers mutually agreed that language based scaffolds are required to teach vernacular medium students. This gives us direction for further literature review in the area of scaffolding. Language based scaffolding is provided under the area of bilingual education.

How much primary language is required?

Studies on English medium classrooms in some post-colonial countries or cities found teachers used as much as 85% of primary language in lessons with English being the 'official' MoI (Probyn 2006; Wannagat 2007). Macaro (2005) suggested a threshold of 10–15% use of primary language in English learning classrooms, beyond which the purpose of using primary language (to facilitate interaction and/or English learning) changes and English learning may be adversely affected.

2.5.3. Use of educational videos

In the qualitative study presented in Section 2.2, we found that students prefer videos over books and classroom. Based on this finding we explored the use of videos in educational settings. This section presents the findings from literature about the benefits of educational videos, various types of educational videos and how does use of videos solve problems of the classroom environment.

Some benefits of using video lectures, such as low cost and high availability, are well-known (Bowers, Dent, & Barnes, 2009). Students and teachers also agree that such videos should be translated into local languages (Ravi & Jani, 2011).

2.5.3.1. Types of educational videos

Several ways are used to create educational videos. We can classify educational videos in two main categories based on their production style 1) camera videos and 2) screencast. Camera videos are recorded with the use of video camera this can record instructor and his activities with the objects in real world. “Screencast” is the term used for the type of videos where activities of a computer screen are captured in a video. Further these categories can be divided on the basis of what material is being used in the videos. Researchers working on MOOC (Guo, Kim, & Rubin, 2014) summarize 4 most used style in educational videos. These styles are a.) Classroom lectures, these videos are recorded during teacher taking a lecture in classroom settings using chalk & talk method, b.) Talking head, shot of an instructor at a desk, c.) Khan Academy, using digital pen to write on screen and d.) Powerpoint slides presentations.

Student’s engagement with the video depends upon the types of videos and time. Based on an empirical study on MOOC videos Philip, Juho and Rob made some guidelines to create effective and engaging educational videos. These guidelines are given in next section.

2.5.3.2. Guidelines to create effective and engaging educational videos

Videos creation is a difficult and time-consuming process. It needs proper planning to make effective educational videos. The study conducted on 6.9 million video watching sessions across 4 courses on MOOC platform (Guo et al., 2014) show some interesting and useful insights on how students interact with the videos. These insights help in developing guidelines for educational video creation. Findings from the study based on types of educational video and their length are given below:

Types of educational video:

- Classroom recorded videos are not engaging even when recorded in high quality and chopped into small segments for MOOC.

- Khan-academy style videos are more engaging than PowerPoint slides or code screencasts.

- Talking head videos with slides are more engaging than talking head videos alone.

Create short videos: Video length is the most significant factor that decides engagement with the video. Shorter videos are found more engaging than long videos. Student's engagement time with the videos is reported to be 6 minutes. Students watch half of the video if the video is longer than 9 minutes and shorter videos, up to 3 minutes, had the highest engagement report.

2.5.3.3. Benefits of screencast-based self-paced learning

A screencast is a type of educational video that is created by recording the computer screen with the activities of a computer screen (Guo et al., 2014). Screencasts are generally recorded with audio explanation using which an instructor can record oral explanation of the educational content being recorded.

While learning by watching screencasts, students can maintain their level of concentration by breaking the lecture into smaller chunks (Ellis, 2008). If they miss something in screencasts because of less level of concentration they can rewind and replay the screencast. This flexibility is not available in the classroom.

The distractions, available in the classroom, are not possible while student learning by watching a screencast because students need to put earphones that leave no or very little room for the student to hear classroom noise (Simpson, 2006). Screencasts are generally viewed in one to one mode and students need not to struggle to see what is written on the whiteboard or projected by the projector. Screencasts create the impression as a learner is sitting quite close to the lecturer (Simpson, 2006).

While learning from screencasts, they know that these screencasts are available to them for multiple viewings so they do not focus on writing down everything (Ellis, 2008). They give more time to understand the material presented in screencasts rather than note it down.

In a pilot study conducted by Simpson (Simpson, 2006) students who were studying in secondary language prefer screencast over the traditional classroom environment. Students who were part of the study also found video player controls acting as a scaffold for better learning as a student reported that "English is not my native language. 'Pause' allows me to check the word I do not know immediately."

In a comparison of text vs screencast based instruction authors found that students who were watching screencasts, they take less time to learn statistics concepts, less time to solve the problem and scored higher compared to those who learn from text-based instructions (Lloyd & Robertson, 2012).

In the literature survey conducted in this section we found that screencast in 1:1 environment itself act as a scaffold for the learners, even for those whose primary language is not English. Students who learn from screencasts have more chances to concentrate on study material than a classroom environment. Students self-reported that they preferred screencasts over traditional classroom environment.

2.5.4. Teaching computer programming

In research cycle 1, we found that students did not perform well in post-test scores and one of the reasons of their low performance was the topics chosen for the intervention. This created the need to use standard curricula that suggest appropriate topics with learning objectives. This section presents the topic and learning objectives for which we design intervention in RC2 to RC5.

The joint task force on computing curricula decides computer science curricula 2013 (Joint Task Force on Computing Curricula & Society, 2013). This curriculum presents four core-tier1 knowledge units related to programming. These knowledge units and time required to teach these knowledge units are given in Table 4.

Table 2.4: Knowledge units and time required to teach

Knowledge Unit	**Core-Tier 1 hours**
1. SDF/ Fundamental Programming Concepts	10
2. PL/ Functional Programming	4
3. PL/ Object Oriented Programming	3
4. PL/ Basic Type Systems	1

Among these four knowledge units we choose 1st (SDF / Fundamental Programming Concept) for our research experiments because this is independent of all other knowledge units. This unit builds the foundation for core concepts in the Programming Languages knowledge area.

Topics to cover selected knowledge unit are given in Table 2.5. The learning objectives related to this knowledge unit and recommended level of mastery are given in Table 2.6. Learning objectives and their required level of mastery are same as given in CS2013 curricula.

We added one more topic T0 (Table 2.5) to give a brief introduction to programming languages and one learning objective LO9 (Table 2.6). We also decided to teach only integer data type from T2 and removed 'iterative control structures' from T5 because it is not required to teach T6 & T7 (Turbak, Royden, Stephan, & Herbst, 1999).

Table 2.5: Topics to cover knowledge unit SDF/ Fundamental Programming Concept

Topic number	Topic	Time required to teach (Hours)	Training Day
T0	Introduction to Programming languages	1	Day 1
T1	Basic syntax and semantics of a higher-level language	NA	NA
T2	Variables and primitive data types (e.g., numbers, ~~characters, Booleans~~)	1	Day 2
T3	Expressions and assignments	1	Day 3
T4	Simple I/O	1	Day 3
T5	Conditional and ~~iterative control structures~~	1.5	Day 4
T6	Functions and parameter passing	1.5	Day 5
T7	The concept of recursion	1.5	Day 6

Table 2.6: Learning objective and their required level of mastery

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

ACM CS curricula 2013 (Joint Task Force on Computing Curricula & Society, 2013) also defines the meaning of each level of mastery that is given below.

Knowledge : The student understands what a concept is or what it means. This level of mastery provides a basic awareness of a concept as opposed to expecting real facility with its application.

Application : The student is able to apply a concept in a concrete way. Applying a concept may include, for example, the ability to implement a programming concept, use a particular proof technique, or perform a particular analysis.

Evaluation : The student is able to consider a concept from multiple viewpoints and/or justify the selection of a particular approach to solve a problem. This level of mastery

> implies more than the application of a concept; it involves the ability to select an appropriate approach from understood alternatives.

Research shows that live-coding is an effective method to teach computer programming (Gaspar & Langevin, 2007).

2.5.5. Bilingual Education

We conducted literature review when students reported using a mix of primary and secondary language in interviews (Section Confirming findings of literature in Indian context2.2). Literature review (Section 2.5.2) shows that teachers use two languages to solve the problems of vernacular medium students. This section presents the literature review on bilingual education.

2.5.5.1. What is bilingual education?

Bilingual education is about using two languages in teaching academics, in a primary and secondary language. In most of the cases English is the secondary language and primary language is used in K-12.

2.5.5.2. Goals of bilingual education?

Fred Genesee (Genesee, 2004) defined three features of bilingual education in the context of school education: 1) linguistic goals, 2) pedagogical approaches and 3) levels of schooling. He mentioned that one goal of bilingual education is to achieve competency in both languages (primary and secondary) by using both languages as MoI for significant portions of the academic curriculum.

These are the various goals of bilingual education:

1. One of the main goals of bilingual education is to make learners fully proficient in their first language and high level of proficient in the second language.
2. One of the goals of education is that students will be able to understand the concepts better. If student will not be able to understand the medium of instructions how can we think of conceptual understanding of the subject.
3. The goal of bilingual education at school level has one more major goal i.e. *"be proud of their heritage, so they become upstanding global citizens as they learn to function beyond cultural boundaries* (McConnell, 1980)*"*.

The goal of bilingual education in computer science undergraduate programs is to make students proficient in English because most of the books and news related to computer science are reported in English.

Fred Genesee (Genesee, 2004) defined the goals of bilingual education in the context of school education that doesn't seem to be fit in the context of undergraduate education. The vernacular medium students we are targeting in this thesis are undergraduate students and proficient in the primary language. Our goal behind using bilingual education is to increase student's competency in the secondary language.

Bilingual education and students' social context of choice

'Social context of choice' is defined by R. Schmidt as "the necessary and inevitable social ground on which we make our personal decisions about what leading a good life entails for us." (Schmidt, 2000). Knowledge of more than one language helps in expanding the social context of choice of a person. Bilingual education makes a learner proficient in the secondary language. It may make a learner able to interact comfortably in a secondary language with people predominantly belong to the mainstream culture, which is often regarded important for career and academic success. A student who don't know English (secondary language) will not be able to work in international workplaces hence primary language only MoI limits the social context of choice of a student.

Teaching students in a primary language only MoI will result in high academic performance and good understanding of the subject but it will reduce their social context of choice (Liu, Li, & Zuo, 2011; Moses, 2000).

While the use of primary language only instructions will limit the social context of choice of vernacular medium student the English medium only instructions will lead to lag in the academics. Bilingual education expands the social context of choice of a student. Good bilingual education, then, will help students learn English and educational content at the same time.

2.5.5.3. Bilingual Education in Practice

This section presents some models of bilingual education being used around the globe-

90–10 model for dual language program: In this model primary language is used 90% of the time in early grades and gradually increase proportion of instruction in English until sixth grades, when both languages are used equally in instructions (Montague, 1997).

50–50 Model for dual language program: In this model (Gómez, Freeman, & Freeman, 2005), students learn in each language about half the time throughout the program. There are various ways to divide the time like Half day and half day, Alternate day, Alternate week.

50–50 content model: This model was developed originally for schools in Rio Grand Valley (Texas) by L.Gomez and R. Gomez (Gómez et al., 2005). Primary language of students was Latino, Upto 5th std. Students were taught using their own language and English. In this model use of MoI was divided by subjects.

Immersion program: use of single language which is not the students' home language.

Maintenance bilingual teaching: use of students' home language when student enters schools but later a gradual change to the use of second language for teaching some subjects and the home language for teaching other subjects.

Transitional bilingual teaching*:* use of students' home language when student enters school but later change it to the secondary language only.

Two way bilingual teaching: instructions given in two languages to students, usually in same classroom with the goal of the students becoming proficient in both languages.

2.5.6. Cognitive load

2.5.6.1. Visualize educational content types to reduce intrinsic cognitive load

Information-processing system of human consists two separate channels, an auditory/verbal channel and a visual channel (Mayer & Moreno, 2003). Verbal channel process the auditory input while visual channel process the data received in pictorial form. Utilizing both channels reduces the cognitive load while use of only one channel overloads the working memory. Instructors in classroom utilizes both channels to deliver instructions. We have already discussed the use of videos in education in section 2.5.3. Videos are the form of multimedia and utilize both channels to reduce cognitive load. (Mayer & Gallini, 1990) shows that the prior knowledge of content is the most important difference affecting the value of graphics for educational purpose. It is suggested that graphics should be used for novice learners as the lessons with graphics greatly improved the learning of novices. Our audience, learning programming in CLIL environment, is novice in terms of content and use of secondary language, we decided to use graphics to teach our learners.

We conducted literature review to design effective instructions that can reduce the cognitive load of learners. This section presents the visualization guidelines to teach various educational content types

Videos can capture the learning material to teach content as well as the presentation style of the instructor. So, we conducted literature review on teaching educational contents using multimedia and using multimedia to present content. Next section 2.5.6.2 presents the literature review on multimedia principles to reduce cognitive load.

Educational contents are classified into 5 categories, fact, process, procedure, concept and principle. Visualization guideless to reduce cognitive load in teaching these content types are given below:

2.5.6.1.1. Teaching procedures

Procedure is a near-transfer or routine task that consists well-defined steps to complete a task. Common procedures in a computer programming course can be writing a program, compiling a program. Learners will perform several step-by-step actions in the same order to complete the task each time. In addition to actions procedures can also include decisions based on some conditions. For example, during hand-execution a learner had to make decision based on the current programming statement. Taking decision becomes more complex if hand-execution is done in a computer program that has conditional and/or branching statements.

Clark (Ruth Colvin Clark & Lyons, 2004) suggested 3 techniques to teach procedures, 1) provide high-level overview, 2) demonstrate the steps of the procedures, 3) offer practice and provide feedback. High-level overview can be provided by orienting learner into the job context in which the procedure is used. Procedures should be demonstrated with the help of same tools or components as the ones used on the job. Assign practice in the similar environment and provide feedback.

The main graphics element in learning material should be the visuals of the actual equipment or actual settings in teaching procedures. Full screen captures in teaching software procedure (van der Meij, Blijleven, & Jansen, 2003) has significant learning benefits than text alone or capturing part of screen instructions. Learners take 25% less time to complete the learning and performed 60% better in retention skills. On a procedural learning task on connecting registers authors (Marcus, Cooper, & Sweller, 1996) reported increased efficiency when they used diagram only compared to text only instructions. Similar effect of visual displays are reported over text only instructions (Watson, Butterfield, Curran, & Craig, 2010) where learners performed a 35 steps assembly task in 28% less time.

Dynamic visuals like animations and/or videos are reported more beneficial than static visuals. (Watson et al., 2010) found that using animated visuals in teaching a 35 steps procedural task result in improved efficiency than using static visuals. Learners learned from animation take 28% less time to complete the task than those who learned from static visuals. Procedural tasks like tie complex knots (Ayres, Marcus, Chan, & Qian, 2009) and perform origami folds (Wong et al., 2009) on school students reported better results when used videos than using static images. Students who watch from videos make less mistakes in performing both tasks. It is suggested to use attention cues to direct attention in a highly visual environment to teach procedures.

2.5.6.1.2. Teaching concepts

According to Clark - ‘Concept is a category of objects or ideas usually designated by a single word. Each object that belong to the concept exhibits common features as well as unique features.’ (Ruth Colvin Clark & Lyons, 2004). For example, variable is a concept, each variable possess a value, name and memory address in the context of computer programming. Similarly, function, branching statement and recursion are various concepts in computer programming. Different subjects has different concepts associated with them. These concepts are known as the backbone of the subject. Concepts is said to be learned only after its mental model is stored in the long term memory. After learning a concept, learner can identity various instances of the concept because of the mental model stored in long term memory.

Concepts can be concrete or abstract. Objects that belong to concrete concepts have parts and boundaries like IDE (integrated development environment). Instances of concrete concepts can be shown with the representational visual. Objects of abstract concepts like variable and function represent an abstract idea. A short scenario and analogy can be used to teach the concept.

Clark (Ruth Colvin Clark & Lyons, 2004) suggested few guidelines to make effective mental model of the concept. A concept can be taught with the help of 1) definition, 2) two or more examples, 3) one or more counter-examples, and 4) analogies. He suggested to follow contiguity principle by placing all information near one another on a page or a screen. Visual or real counter examples should be shown to tell what the concept is not. Analogies should be a) familiar to target audience, b) drawn from the different content area, and c) indicative of how the analogy is related to a specific feature of the concept (Newby, Ertmer, & Stepich, n.d.). Related concepts should be taught together and using organizational graphics (e.g. table, matrix etc.). One should engage learners to process the concepts using visuals, as the students who take time to study effective visuals learn more than those who skip the visuals (Gyselinck & Tardieu, 1999; Schnotz, Picard, & Hron, 1993).

2.5.6.1.3. Teaching facts

Facts are unique, specific information about objects, events, or people (Ruth Colvin Clark & Lyons, 2004). Program execution starts from main function, *if* is a conditional statement, Meaning of a '*0*' in return statement are all the examples of facts. A learner should know the factual information to perform basic tasks. As human memory often fails to recall factual information, it is important to teach facts with extra care.

Clark provides two guidelines to teach facts. Firstly, teach facts in job context and secondly, provide memory support. During teaching programming languages we want to teach the use of various icons and menu-items of an IDE or the use of various keywords in a computer program. A common mistake done is to teach all the icons and menu-items in one lesson or all keywords in one lesson. The result will be boring lecture and intrinsic cognitive overload as our working memory is limited to process 7 ± 2 independent elements only. Facts should be taught with the relevant lesson content in the context where this fact will be used. For example, tell students that 'the execution of the program starts from main function' at the time of teaching the process of program compilation and execution.

Use representational visuals displayed in job context. For example, when we want to teach the use of 'compile' icon, we should teach in real context by showing the IDE and by compiling the program while teaching related procedure. If real job context has many elements then use attention cues during the discussion.

2.5.6.1.4. Teaching process

Processes are the descriptions of state changes that communicate how systems work (Ruth Colvin Clark & Lyons, 2004). Process can be related to technology, business or scientific methods. Process can be linear or cyclic. 'How does a simple program works?' is a simple process while 'How does a recursive function work?' is an example of cyclic process.

(Hegarty, Narayanan, & Freitas, 2002) defined three main learning phases as process, decomposition, building casual model and building dynamic model. During decomposition phase leaner breaks whole system into small parts and learn their names and working. In causal model phase, learner builds a cause-and-effect model of how working of a component affects the working of another component. During dynamic model phase, learner thinks about whole system and mentally animates it to understand the working of the whole system.

Visualization guidelines for each content type are presented below: These guidelines are summarized by clark and lyons (Ruth Colvin Clark & Lyons, 2004).

Guidelines to teach *procedures*

- Provide demonstrations that combine transformational and representational visuals.
- Demonstrate procedures with dynamic visuals.
- Manage mental load.
- Use visuals to draw attention to warnings.
- Design online procedure practice exercises effectively.

Guidelines to teach *concepts*

- Display teaching methods in a contiguous manner.
- Create visual counter examples.
- Use visual analogies.
- Display related concepts together.
- Use organizational graphics for related concepts.
- Promote learner engagement with concept visuals.

Guidelines to teach *facts*

- Use representational visuals displayed in job context.
- Display facts for visual contiguity.
- Use organizational visuals for multiple facts.
- Use relational visuals for numeric trends.
- Promote engagement with important factual visuals.

Guidelines to teach *process*

- Use transformational visuals that show state changes.
- Use simpler visuals to promote understanding.
- Manage load when presenting process visuals
- Use interpretive visuals to represent abstract processes.
- Promote engagement with process visuals.

Guidelines to teach *principle*

- Use representational visuals for problem-centred learning components.
- Use multimedia dynamic visuals to display case scenarios.
- Use animated learning agents to model critical thinking skills during problem-solving demonstrations.
- Use graphic design devices to manage mental load during problem - centred learning.
- Analyze video / audio recorded work examples.
- Engage learners with explanatory visuals including visual simulations.

2.5.6.2. Multimedia principles to reduce extrinsic cognitive load

A screencast can contain static content (e.g. images, graphics, illustrations or text) and dynamic content (e.g. way of presentation, animation). It is important to apply multimedia principles in both, static and dynamic types of contents else effect of using multimedia will reduce and students will face high cognitive load. This section presents literature review of multimedia principles that can impact the creation of static and dynamic content.

According to the cognitive load theory (CLT), extraneous cognitive load depends on content presentation style. Change in presentation style may increase or decrease the extraneous cognitive load. Cognitive load is decided on the basis of extrinsic and intrinsic cognitive load and decrease in extraneous cognitive load decreases the total cognitive load of the learner and frees up working memory resources (John Sweller, 1994). As content presentation can reduce extraneous cognitive load it is important to pay extra attention to it during instruction design. This section presents a detailed literature review of some techniques that follow multimedia principles and cognitive load theory to reduce cognitive load of the vernacular medium students.

The state of educational content changes over time during presentation irrespective of where it is being presented, in a class or in a video. There are few differences between the content being presented in classroom and the one being presented in a video. Firstly, learners cannot control the pace of the content in a classroom while they can do so in a video. Secondly, in a classroom environment, learners cannot just focus on the content as there are teachers, peers and other distractions.

2.5.6.2.1. Split-attention effect

When learning material consists more than one source of disparate information, students need to mentally integrate it in order to comprehend the information. This effect is known as split-attention effect (John Sweller & AYRES, 2006). This increases extraneous cognitive load and eventually leads to poor learning.

This effect can be reduced in printed learning material by placing text near to components of picture. This way they can see both the information at the same time and will be able to make the sense out of the presented material. In dynamic visuals (e.g. animation, videos or simulations) split-attention effect can be reduced by using both verbal and visual channels simultaneously. Literature reports that students perform better if they receive information using animation with narration rather than animation with text (Mayer & Moreno, 2003). Presenting information using both visual and auditory channels is called off-loading.

2.5.6.2.2. Segmenting and pre-training

Off-loading helps in reducing split-attention effect but using both channels for instruction delivery increases the high-intrinsic load if the content is conceptually complex (J Sweller, 1999). Research suggested using segmenting and pre-training to reduce intrinsic cognitive load.

Mayer and Moreno suggest using learner-controlled segments by segmenting complete information into multiple segments and allowing students to navigate through them. In an experiment done on teaching to tie several types of knots authors made two types of videos: interactive and non-interactive (Schwan & Riempp, 2004). Interactive videos included play controls like play, pause, increase or decrease play speed, and jump. Learners were divided into two groups. First group watched the interactive videos while second group watched the non-interactive version of the same videos. After watching videos all participants were able to tie all kind of knots. However, those in the interactive version learned from 66% to 95% faster. It is seen that learners used play controls a lot. Usage of video control increased with the increased difficulty of tying the knot.

Pre-training is also a way to reduce split-attention effect. In processing a narrative screencast explaining how a recursive function works, learners must simultaneously build component models (how if statement and function call work) and a casual model (what happened when condition is true or false). Constructing mental model required building these two models, component and casual. Component models of various programming construct can be built using pre-training. Once the component models are built, students can devote their cognitive processing in building casual model from the narrated screencast. Without pre-training, students will try to build causal and component model simultaneously that can easily overload their working memory (Mayer & Moreno, 2003).

2.5.6.2.3. Redundancy effect and Verbal redundancy

Redundant presentation is a multimedia presentation that consists of animation, narration and on-screen text. This is called redundant presentation as the words are presented both as narration and simultaneously as on-screen text (Mayer & Moreno, 2003). Learner devotes cognitive processing in reading on-screen text and matching it with simultaneous narration. In an experiment, Mayer showed that students who watched non-redundant presentation performed better than those who watched redundant presentation. Mayer named this effect as redundancy effect where “Students understand a multimedia presentation better when words are presented as narration rather than as narration and on-screen text.” In further investigation, Mayer found that students learnt better from a redundant presentation if animation is not the part of presentation. Authors named it *verbal redundancy* where presentation has words in both on-screen text and narration but animation is not the part of presentation. Adding onscreen text does not overload the visual channel because it does not have to compete with the animation.

2.5.6.2.4. Attention cueing/signalling

Cueing is non-content information that captures attention to those aspects that are important to the content (de Koning, Tabbers, Rikers, & Paas, 2007). Purpose of cues is to guide the learners cognitive processing, not to provide new information (Mautone & Mayer, 2001). In a study, authors (Mautone & Mayer, 2001) found that signalled text has positive impact on knowledge transfer that increases student's problem solving ability. Text was signalled by braking into paragraphs with more heading than non-signalled text and making some words bold, italic, and bigger in font-size.

If content is presented with many visual elements and involve several simultaneously occurring events, it may not be effective for learning till it is presented in a way that extraneous load is minimised. Signalling or attention cueing is used by authors to reduce extraneous cognitive load. Authors used arrows and other symbols, colour and bold text as a signalling mechanism in content presentation. Several studies are conducted to measure the effect of attention cueing on learner's conceptual understanding, knowledge transfer, retention skills and mental efforts required to comprehend the material.

Authors (de Koning et al., 2007) identified how attention cueing affects learning in visual-only instructions in non-narrative animations. Cueing reduces the working memory resources that can be used in content learning (de Koning et al., 2007). Authors also found that cueing helps learners in forming more cohort schema. In a study, authors found that signalling is not only helpful in animated instructions but also in verbal only instructions (Mautone & Mayer, 2001). Authors also found that the signalled animated instruction that was presented with signalled verbal explanations had the higher impact in instruction retention and knowledge transfer than non-signalled animated instruction presented with non-signalled verbal explanation (Mautone & Mayer, 2001).

It has been reported in the literature that signalling is useful for highly visual environment that has many elements to focus on, as it reduces visual search (de Koning et al., 2007) and reduces extraneous cognitive load. Although use of signals in a low visual environment, in which visual search is not cognitively demanding, does not have any negative impact on learning and knowledge transfer. In a study (de Koning, Tabbers, Rikers, & Paas, 2011) where authors measured the effect of cueing on the rate of information presentation speed, they found that cueing does not show any effect on either of learning or transfer in both settings. However, authors noted high cognitive overload required to process the information if the content is presented in slow speed.

2.5.6.2.5. Synchronization

Mayer suggested using synchronization to reduce the cognitive overload that occurs when learner tries to select, organize and integrate material from a complex visualization (Mayer & Moreno, 2003). Synchronously presenting the audio and visual information is known as synchronization. When both of these information are presented simultaneously a learner does not need to hold the information in one channel to understand the information presented from a different channel.

Chapter 3

Research Method

In this research work, the problems of vernacular medium students were explored through related work analysis. Most of the existing methods try to solve the problem by satisfying either the limitations of practical context or goals of bilingual education. I did not find a research study that tried to incorporate both into research design. The main research issue was to find a way to teach vernacular medium student and develop the guidelines to design learning material for educators that works in the limitation of practical context and fulfils the goals of bilingual education. This chapter presents an overview of how research was carried out to develop interventions for vernacular medium students. Five iterations of the research cycle were carried out to reach to the desired result and outcome.

3.1. Overview of research methodology

The research questions to be addressed play an important role in deciding the research methodology. Research design followed in this thesis is known as Educational Design Research (EDR) development study (Plomp & Tjeerd, 2013).

Education design research is defined as - *"The systematic analysis, design and evaluation of educational interventions with the dual aim of generating research-based solutions for complex problems in educational practice, advancing our knowledge about the characteristics of these interventions and the processes of designing and developing them."* – (Plomp & Tjeerd, 2013, p. 153)

The education design research is used when requirements are not just to design the intervention but to design a set of design principles (McKenney, Nieveen, & van den Akker, 2006). The goal of this research is to develop a research based intervention and construct guidelines for instructors to develop instructional material as a solution to the problem of teaching-learning vernacular medium students within the limits of practical context while achieving the goals of bilingual education. Thus, EDR seems to be an appropriate method to use for the research.

Educational design research process incorporated a systematic educational design process which include need analysis, design & develop prototype, evaluation and problem resolution as four phases as presented in Figure 3.1 (Plomp & Tjeerd, 2013, p. 17). The analysis phase in my research deals with the need analysis of vernacular medium students and practical context. Design and develop prototype phase includes either development or selection of appropriate study material based on the need analysis phase. In evaluation phase I try to find out the problems in learning material selected or developed in design & develop prototype phase. Problem resolution phase presents the learning of current research cycle and how to move to the next cycle.

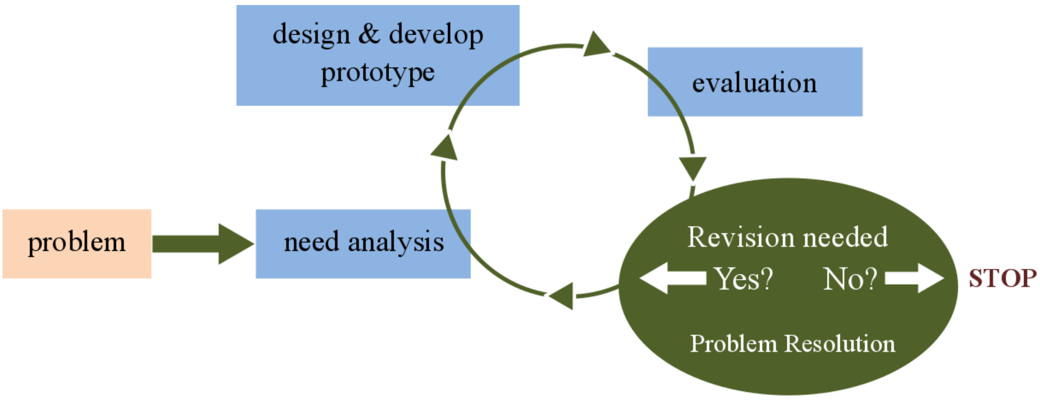


Figure 3.1 Iterations of systematic design cycles

The solution approach includes four research cycles. Each research cycle takes input from multiple data sources including learning from previous research cycle, literature review and experience of students or teachers. A prototype of learning material is designed and pilot study or experiment was conducted and analysed to answer the RQs of this thesis.

A more generic design research model of systematic design cycles (Figure 3.1) is developed by Wademan and presented in Figure 3.2 (Wademan, 2005). This generic design shows the possible steps for each phase of research cycle. The figure shows each phase of a research cycle and steps in each phase that can be followed by researchers. In this thesis, we adopted this model as it is giving opportunity to create a prototype by considering principles in its design and involve both researchers and users.

We had to repeat this research cycle 5 times to reach to the final desired prototype. In each research cycle we followed one or more activity for each phase. We mapped one iteration of systematic design cycle (Figure 3.1) with the generic design research model (Figure 3.2). Problem is mapped with "problem identification phase", need analysis is mapped with "identification of tentative products and design principles", design and develop prototype phase is mapped with "tentative products and theories" and evaluation phase is mapped with "prototyping and assessment of preliminary products and theories" and last phase problem resolution is mapped with "problem resolution and advancing theory". Each research cycle consists of four phases, details of each phase of research cycle is given in Section 3.1.1 through Section 3.1.4 of this chapter.

3.1.1. Need analysis phase

The need analysis phase used in our work is for the identification of tentative products and design principles with the help of literature review, problems in previous research cycle, consulting experts or practitioners and analysing the practical context. Output of this phase is used to select the principles and theories to conceptualise the prototype of the learning material. Analysis of promising examples, consulting the experts & practitioners, analysing the promising examples and focused literature review are the four components of this phase of education design research cycle, as given in Figure 3.2. In each research cycle, one or more of these components are used to identify the principles, theories and approach to develop prototype of intervention.

In this phase of first research cycle (RC1), literature review is conducted to identify possible solutions for the problems of vernacular medium students. In second research cycle (RC2), this phase is used to resolve the problems of RC1 using literature review for the use of videos in education. In the phase of RC3, literature review on visualization of instructional design and multimedia principles is conducted to reduce the cognitive load of students. Literature review on bilingual education was conducted in the phase of research cycle 4 (RC4). In research cycle 5 (RC5), literature review on the problems of classroom environment was conducted. Table 3.1 presents details of each phase of each research cycle used in this thesis.

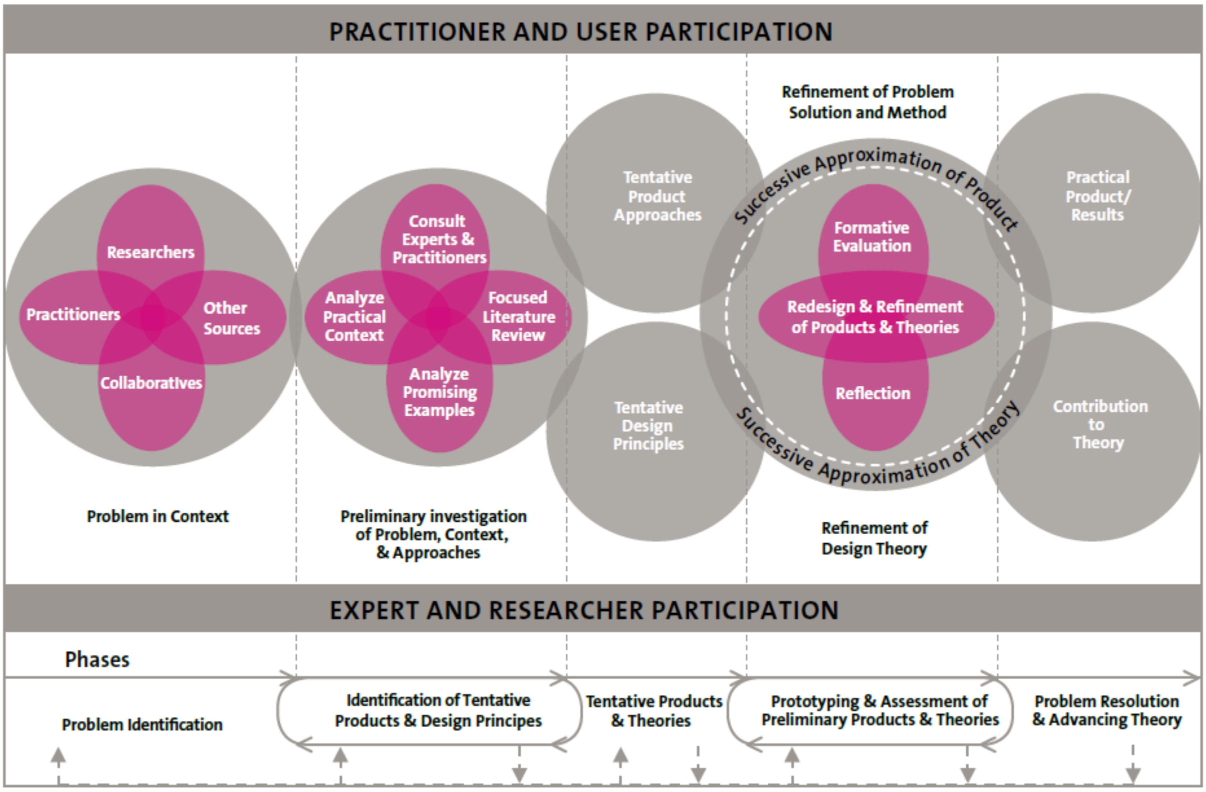


Figure 3.2 Generic design research model (Wademan, 2005)

3.1.2. Design and develop prototype phase

This is the educational material development phase of EDR methodology. In this thesis, the focus is on the development of learning material to scaffold vernacular medium students, who are the targeted learning outcomes of the intervention. We have either developed learning material or chosen appropriate learning material at the end of this phase in each research cycle. The prototype developed in this phase in each research cycle was based on the findings of its previous research cycle and need analysis phase of the current cycle. The approach was to use the prototype practically. We also designed a research method in this phase of research cycle to get the result for the evaluation phase. The experiment design was based on the requirements of the research question of the current research cycle. We used quantitative analysis or qualitative analysis or both in this phase.

In this phase of first research cycle (RC1) we selected first prototype “classroom recorded video tutorials”. In second research cycle (RC2), this phase is used to select second prototype “short educational screencasts”. In this phase of RC3, properties of third prototype is designed and “cognitively-scaffolded screencasts” are selected. Fourth prototype “cognitively scaffolded learning material in bilingual MoI” is designed in this phase of research cycle 4

(RC4). In research cycle 5 (RC5), final prototype "cognitively scaffolded screencasts in English only MoI and bilingual MoI" was created and tested. Table 3.1 presents details of each phase of each research cycle used in our work.

3.1.3. Evaluation phase

Evaluation phase is used to find out the effectiveness of the prototype in each research cycle. Expected and actual effectiveness is measured in various research cycle as per the requirement of the prototype. To measure the expected effectiveness focused group method is used with the teachers. Micro-evaluation method and try-out methods are used to measure the actual effectiveness. Focus-group and micro-evaluation methods are used for qualitative study while try-out method is used for quantitative study to measure the effectiveness of the prototypes in each research cycle.

In this phase of first research cycle (RC1) try-out method is used when the prototype was used in a classroom environment. In second research cycle (RC2) this phase is used to check expected effectiveness of the prototype using focused group with instructors and actual effectiveness using micro-evaluation method with students. In this phase of RC3, actual effectiveness with the students is measured in a qualitative study. Actual effectiveness is again measured with try-out method in this phase of research cycle 4 (RC4). In research cycle 5 (RC5), try-out method is used in a quantitative study. Table 3.1 presents details of each phase of each research cycle used in this thesis.

3.1.4. Problem resolution phase

Problem resolution phase is the last phase of the research cycle. It is used to present the learnings and findings of current research cycle. These findings can be in the form of a theory or results that lead to the next research cycle. The last research cycle in our work produces learning material that can be used by teachers, researchers or students for their benefits and/or guidelines to create the product for the teachers or researchers. The literature review presented in solution space (Section 2.5) is guided by this phase of each research cycle.

3.2. Ethical considerations

As with any research involving human participants, ethical considerations needed to be followed (Cohen, Manion, & Morrison, 2000) in our work as well. The guidelines followed in this thesis for studies involving human participants are as under:

Informed consent: Students were given consent form before start of the experiments and were asked to fill these forms before participating in the experiment. Thus written consent of students was made available. They were given flexibility to leave the experiment at any point of time.

Anonymity and confidentiality: Students were assured that the data collected in our experiments has no connection with their term work or test marks. They were also informed in writing that the data is only for research purpose and confidentiality would be maintained.

3.3. Summary

This chapter explains how the research questions were answered using education design research (EDR) method. Each research cycle followed in the thesis has four phases: need analysis, design and develop prototype, evaluation and problem resolution. Need analysis phase is carried out using literature review and findings from previous research cycle. Specific research questions were the outcome of need analysis phase. Prototypes were either selected or designed using the properties identified in need analysis phase in "design and develop prototype" phase. Evaluation phase is used to evaluate the prototype for the effectiveness on students. Problem resolution phase is used to identify the problems in the prototype and to set goal for the next research cycle. We found the desired prototype in fifth research cycle. Detail of each research cycle (RC1 to RC5) is presented in Chapter 4 to Chapter 8 respectively.

Table 3.1 Detail of each phase of education design research in each RC used in this thesis

	RC1	RC2	RC3	RC4	RC5
Research methods →	**quantitative**	**qualitative**	**Qualitative**	**quantitative**	**quantitative**
Phases of research cycle ↓					
Need analysis phase	Literature review is conducted to identify possible solution	Literature review was conducted for the use of videos in education.	Literature review on visualization of instructional design and multimedia principles are conducted to reduce the cognitive load of students.	Literature review on Bilingual education.	Literature review on the problems of classroom environment
Design and develop prototype	First prototype "classroom recorded primary language videos" are decided and selected and post-test scores of students are collected.	Second prototype "educational screencast in primary language" is selected.	Third prototype "cognitively scaffolded educational screencast in primary language" is developed.	Fourth prototype "learning material using two languages in classroom environment" is developed.	Fifth prototype "cognitively educational screencast in English only MoI and Bilingual MoI" is developed.

Evaluation phase	Actual effectiveness of the prototype is measured using try-out method	Expected and actual effectiveness of the prototype is measured using focused group and micro-evaluation method	Expected and actual effectiveness of the prototype is measured using focused group and micro-evaluation method	Actual effectiveness of the prototype is measured using try-out method	Actual effectiveness of the prototype is measured using try-out method
Problem resolution phase	Need of literature review is identified for the use of video tutorials in education.	Need of literature review to effective instructional content development is identified.	Need of literature review on bilingual education is identified.	Need of literature review on classroom problems is identified.	Prototype is found effective for vernacular medium students.

Chapter 4

Research Cycle 1: Classroom recorded video tutorial

In previous chapters, we described the problems of vernacular medium students (Section 2.3) with the limitations of practical context (Section 1.1.1) and the overall research design method to be used (Chapter 3: Research Method). We got to the final intervention after five iterations of education design research model (EDR). We consider one iteration as one research cycle or RC. We named research cycles one to five as RC1 to RC5 respectively. This chapter presents the details of first research cycle (RC1).

In literature review presented in Section 2.1 and qualitative study presented in Section 2.2 we identified the problems of vernacular medium students. Students reported that the use of English MoI created problem in comprehending the instructional material. Students also reported that their first preference of choice was educational videos if videos were using Hindi as MoI or simple English MoI in Indian accent. These findings helped us to decide first prototype that is reported in this research cycle. We used videos to teach introductory programming to vernacular medium students. These videos were selected in two languages, Hindi and English. These videos were recorded by a well-known professor of a reputed engineering college of India and hence Indian accent was used in the video.

In order to validate the student perception of the possible solution, we created following broad research question for this research cycle: RQ1: What is the impact of the medium of instructions (MoI) on the programming abilities of learners from various medium? This is operationalized into the following specific questions:

RQ1.1: Do undergraduate Hindi medium students learning introductory programming by watching video lectures in Hindi, perform better than similar students who watch the same lectures in English?

RQ1.2: Does self-reported prior knowledge play a role in the students' performance?

In section 4.2 we describe the design and develop prototype phase in which we choose a research design to answer the RQ1.1 and RQ1.2 and intervention provided to students. Section 4.3 in this chapter describes the evaluation methods used to measure the effectiveness of intervention. Section 4.4 of this chapter presents the problem resolution phase where we discuss the learnings and findings of first research cycle (RC1).

4.1.Need analysis phase

In this phase of first research cycle we analyse the need of vernacular medium students form literature review (Section 2.1) and qualitative study (Section 2.2).

From the summary of qualitative study (Table 2.3) we noted that 1) Vernacular medium students find it difficult to understand from English MoI, 2) Students prefer use of video tutorials over books if videos are available in Hindi MoI or English MoI with Indian accent. Based on these findings we felt that we should develop a prototype that uses videos using Hindi MoI or English MoI recorded in Indian accent and conduct an experiment to know the effectiveness of the prototype. The assumptions and actions of this research cycle are presented in Table 4.1.

Table 4.1 Assumptions and actions of this research cycle

Assumptions	**Actions**
Vernacular medium students will perform better if taught in Hindi MoI than those who learn from English MoI.	Hindi MoI is used to teach computer programming.
Use of classroom recorded videos will be effective to students	Classroom recorded video tutorials are used.
Using videos in classroom environment where all students are watching it together will result in improved performance.	Videos were played on a projector and all students were watching the same video at a time.

4.2.Development of first prototype: classroom recorded videos

This section presents the details of first prototype used in our work. Section 4.2.1 presents the detailed description of first prototype. Section 4.2.2 presents the description of scaffoldings used in the first prototype.

4.2.1. First prototype: classroom recorded videos

To develop first prototype of intervention we conducted literature review about the problems of vernacular medium students (Section 2.1) and identified possible solutions which are summarized in **Error! Reference source not found.**. In the literature review, use of primary language instructions is reported effective for subjects like mathematics, physics, and chemistry. While there is evidence that instructor driven bilingual education in classroom setting is effective, we considered the points about use of Hindi MoI, suggested by students, and decided to use Hindi MoI for first prototype.

Literature review on use of educational videos, presented in section 2.5.3, revealed several benefits. Students also suggested about the use of videos recorded in Hindi MoI. However, there is not much work on the effectiveness of translated video lectures for student achievement, nor on teaching of programming in primary languages. We found only one work (Hanjing, Kuanquan, & Yuying, 2009), that suggests a bilingual model for teaching programming to undergraduate students in China. Our rationale was to eliminate any bias that may occur due to face-to-face communication, such as the instructor adapting the lecture dynamically based on cues from the students. So, we decided to use video-based classroom environment to answer RQ1.

Programming is considered to be a difficult subject and failure rate of students in this subject is higher. Students were facing problem in understanding this subject with English MoI (Mitra, 2010; Tollefson & Tsui, 2003).

First intervention prototype: This prototype is based on use of primary language as MoI in a classroom setting where all students will watch educational video together. We used three, 1 hour videos in one day workshop to teach introductory programming in a classroom environment in this intervention. Table 4.2 presents the detail of intervention provided in this research cycle (RC1).

Table 4.2 Details of intervention provided in RC1

Elements of intervention	Details of first prototype
Subject	Computer programming
Topic	Introductory programming. LOs are listed in Table 4.5.
Instructional Content	• Three 1-hour videos. • Recorded while teaching in classroom environment.
Treatment	• One day workshop • Classroom environment • Watch videos

4.2.2. Scaffoldings used in first prototype

In this section we present the details of scaffoldings used in the first research cycle. We used only language-based scaffolding for first prototype.

4.2.2.1. Language-based scaffolds

In this research cycle we used two types of classroom recorded videos: 1) recorded in English MoI and 2) recorded in Hindi MoI. We wanted to see the effect of teaching vernacular medium students in primary language (Hindi). Hence, we decided to use vocal Hindi MoI as a scaffold. We believed that the use of simple English will act as scaffold for those who watch English video. We expected that the performance of students watching Hindi video will be higher than those watching English video. Hence, in first prototype we tested two language-based scaffolds. Details of scaffolding in Hindi video is given in Table 4.3 and those for English video is given in Table 4.4.

We used Hindi MoI for vocal explanation because students believed that use of Hindi MoI to deliver content would improve their performance.

Table 4.3 Language-based scaffold in Hindi video

No.	Detail of scaffolding in Hindi video	Where to use
1	Use Hindi MoI	Vocal explanation

We used simple English MoI for vocal explanation and on-screen text to teach other group of students based on the findings of qualitative study presented in Section 2.2. Three findings from that qualitative study helped us to provide this scaffold. 1) Students reported the problem for their learning as non-availability of educational videos by Indian teachers using Indian accent and simple English. 2) Students preferred to read from the books written by Indian authors, because the choice of words in these books is less complex than in books written by foreign authors. 3) Students used English-English dictionary to find simpler meaning of complex English words.

Table 4.4 Language based scaffold in English video

No.	Detail of scaffolding in English video	Where to use
1	Use simple English MoI	Vocal explanation, on-screen text

4.2.3. Selection of learning material

We selected three 1-hour video lectures on introductory programming, delivered in English by a well-known professor. The professor repeated the lectures in Hindi to create the translated videos. These videos were recorded when professor was delivering lecture in a computer programming classroom. The lectures were on the topics: (1) Introduction to Computers, (2) Introduction to C++, and (3) Numerical Computing. Learning objectives with the corresponding video tutorial are listed in Table 4.5.

Table 4.5 Learning objectives for videos of first prototype

Sr. no.	Learning objective (After completing the treatment students will be able to...)	Video no.	Q. no.
1	Describe the need and importance of computer programming.	1	-
2	Identify all valid/ invalid characters in a given c++ program.	1	-
3	Identify valid/ invalid arithmetic operators.	1	14
4	Identify how much memory is reserved for a variable of a given data type.	2	2
5	Differentiate between initialization and declaration statements in a given program.	2	4, 5
6	Identify valid/ invalid use of variable names, keywords in a given c++ program.	2	14
7	Identify valid/ invalid use of brackets in arithmetic instructions.	2	12
8	Calculate an expression according to the given data types.	2	6
9	Write a mathematical equation using appropriate computer programming expression syntax.	2	7
10	Distinguish between valid/ invalid programming expressions.	2	14, 11
11	Solve a programming expression by executing each operator according to its order of precedence.	2	6, 13
12	Determine storage for character variables.	3	8
13	Identify valid/ invalid constants for basic data types.	3	10
14	Describe what will be stored in memory for a given type of variable.	3	1, 9
15	Choose appropriate data type for a variable given its use in a programming problem.	3	3

4.2.4. Research design

We decided to check the actual effectiveness of the prototype, presented in this research cycle. As per the findings of qualitative study, all students agreed that the use of videos recorded in Hindi MoI helped them to comprehend the learning material (see Section 2.2). We wanted to check the actual effectiveness of this prototype. We used try-out method for this as suggested in (Tessmer, 1993). We wanted to test the effectiveness of video tutorials recorded in Hindi MoI on vernacular medium students. In this comparative study, we compared the effectiveness of video tutorials recorded in English MoI with the effectiveness of video tutorials recorded in Hindi MoI. As no study on the effectiveness of the chosen videos was available, we decided to include English medium students in the study to claim that the videos are effective for English medium students as well.

4.2.4.1. Sample

The sample consisted of 93 engineering first year undergraduate students, studying programming in their current semester, of a reputed college in North India. Thirty-one English medium students were selected for EE group and simple random sampling was used to divide Hindi medium students in two equal groups named HH and HE. Groups were divided based on the prior MoI and MoI of the video, as shown in Table 4.6.

Table 4.6 Medium of instruction for various groups

Medium in 12th Std	Treatment	Group (Name)	N
English	English	Baseline (EE)	31
Hindi	English	Control (HE)	31
Hindi	Hindi	Experimental (HH)	31

4.2.4.2. Data collection:

To measure programming ability, performance scores on a post-test were collected. To determine prior academic achievement levels, overall percentage of marks in 12th standard were collected.

4.2.4.3. Instrument

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 use a computer at home (yes or no).

We looked for a concept inventory for programming but found that the standardization of assessment instruments for programming ability is still ongoing (Tew & Guzdial, 2011). So we created the post-test based on questions that typically appear in the University exams and those given in standard textbooks. We used a paper-based post-test containing 14 multiple choice questions, each having exactly one correct answer. We included only those questions that directly mapped to the learning objectives in our video lectures. Learning objective and it's mapping with the post-test question is listed in Table 4.5. We had 14 post-test questions, of which 8 were at the Knowledge and Comprehension level and 6 were at the Apply and Analysis level. One sample post-test question of each level is shown in Figure 4.1. Complete post-test for this research cycle is presented in Appendix I: Post-test for RC1.

(Knowledge level) Q1. In the statement int i='a';
What will be stored as value of variable 'i'?
a) ASCII value of character 'a' [ ] b) 'a' itself [ ]
c) Program will return an error [ ] d) None of them [ ]

(Apply level) Q6. Find the value of i in:
int i = 20 + 6 / 4
a) 21.5 [ ] b) 21 [ ] c) 6.5 [ ] d) None of them [ ]

Figure 4.1 Sample post-test questions

4.2.4.4. Procedure

Survey: We first conducted the survey and then divided the students into 3 groups, based on the MoI of their 12th Std, as shown in Table 4.6. There was no pre-test.

Arrangement: We arranged separate classrooms for the 3 groups. Each classroom was equipped with projector and sound system.

Treatment: We used only classroom recorded video lectures for the treatment. The videos were already publicly available, created under the National Mission of Education through ICT. They were created by recording the classroom lectures given for the CS 101 course at IIT Bombay. The videos not only contain the lectures and slides, but also the screen-capture of demonstrations for writing, running and compiling computer programs. The English recordings were created during normal class hours while the Hindi recordings were created during extra classes specifically for Hindi medium students. Although the lectures in the two languages are not completely identical translations, they addressed the same Learning Objectives (LOs) in nearly the same manner. The list of LOs for the chosen lectures is given in Table 4.5.

Each group watched three 1-hour video lectures, with 30 minutes break after each video, over a total period of five hours. There were no additional tutorials or laboratory exercises. The MoI in the videos was Hindi for the experimental group and English for the other two groups Table 4.6.

Post-test: To investigate the effect of the MoI on achievement scores, we conducted a post-test using the instrument we had designed earlier. The mapping of post-test questions to learning objectives in the videos, is also shown in Table 2.6. Each student had to attempt the post-test individually, within a time limit on thirty minutes. There was no negative marking.

Analysis: We performed quantitative analysis of the post-test scores for the different groups. We computed the means for each group. We used ANOVA to determine which means are significantly different from one another. We used factorial analysis to determine the effect of prior knowledge on the post-test scores.

4.3. Evaluation of classroom recorded video tutorials

We evaluate overall performance of each group and compare them to find the effect of MoI in the treatment, we did not found any significant difference. Than we try to gain insights on the performance of each group for knowledge level and apply level questions and found no clear pattern. We also measure the effect of self-reported prior knowledge for Hindi medium students and again we didn't find any significant difference.

4.3.1. Overall performance

The distribution of post-test scores for the three groups, (EE, HE and HH) is shown in Figure 4.2, and their means are shown in Table 4.7. Here the first letter of the group name represents students MoI in K-12 and second letter represents the MoI in our treatment.

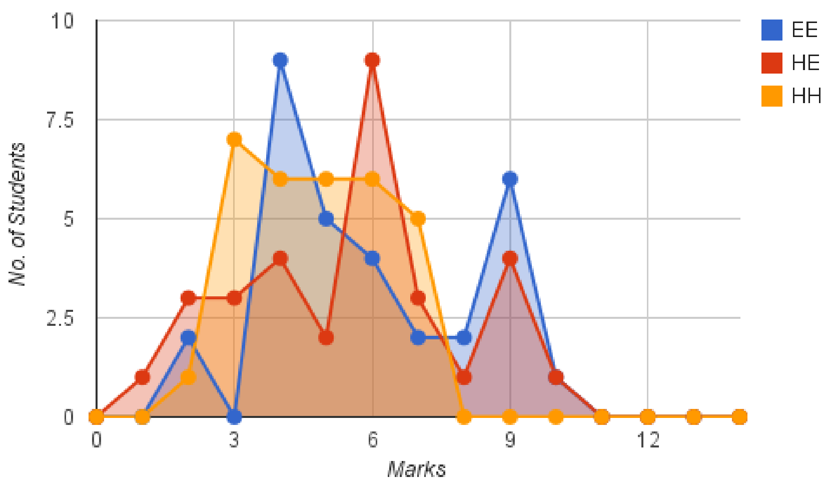


Figure 4.2 Marks distribution of students in each group

Table 4.7 Mean of post-test score of each group

Group	N	Mean (out of 14)	Percent-age	Std. dev	Std. error Mean
HH	31	4.77	34.07 %	1.50	0.27
HE	31	5.52	39.43 %	2.37	0.43
EE	31	5.90	42.14 %	2.25	0.41

We performed ANOVA to determine the variation between groups but did not find the differences to be significant, as shown in Table 4.8.

Table 4.8 ANOVA for the 3 groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	20.409	2	10.204	2.356	.101
Within Groups	389.871	90	4.332		
Total	410.280	92			

The difference between the groups is not significant, as shows in Table 4.8. So, we can say that the performance of students is not affected by MoI in this research cycle. The mean scores, Table 4.8, for each group is low that indicates that students of all groups comprehend very less amount of information presented in this treatment. Not only HE medium perform poorly, as we expected but HH and EE groups also performed poorly and the difference in post-test score is not significant.

4.3.2. Performance at knowledge level and apply level

To investigate at a finer level, we analysed the performance of the groups in two categories of questions, knowledge level and apply level. Knowledge level questions was testing student's understanding of the concept while apply level question was testing whether student is able to apply a concept in a concrete way or not.

- Category 1 consisted of questions at the Knowledge or Comprehension level (Ql, Q3, Q6, Q7, Q8, Qll, Q13), while
- Category 2 consisted of questions at the Apply or Analysis level (Q3, Q6, Q7, Qll, Q13, Q14). The number of students who answered the questions correctly in Category 1 and Category 2 is shown in Figure 4.3 and Figure 4.4 respectively. We did not observe any clear pattern in the Category 1 questions. In Category 2 questions we saw that for each question, the number of students who answered them correctly is highest in group EE, followed by HE and HH.

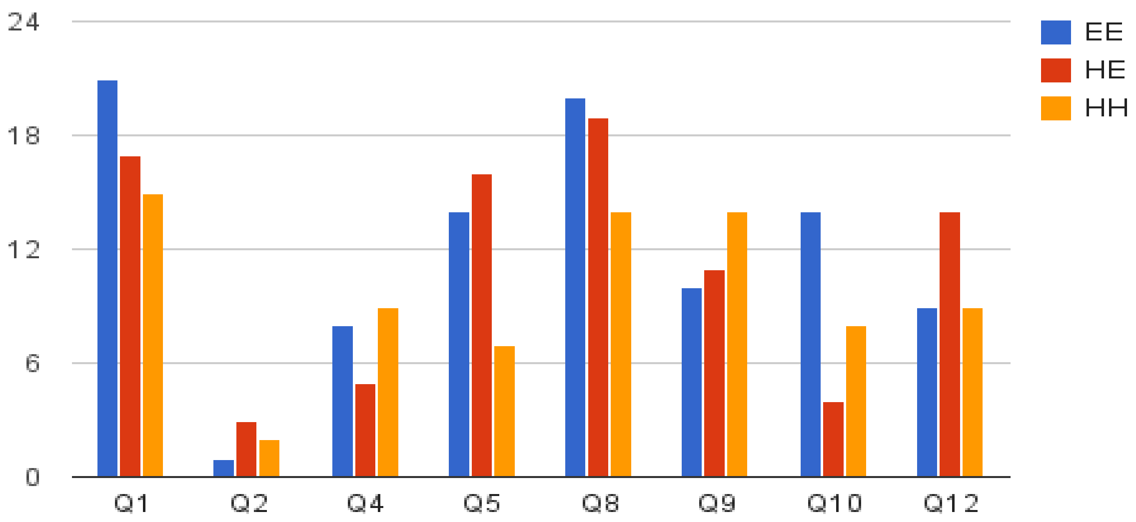


Figure 4.3 Performance in the knowledge level questions

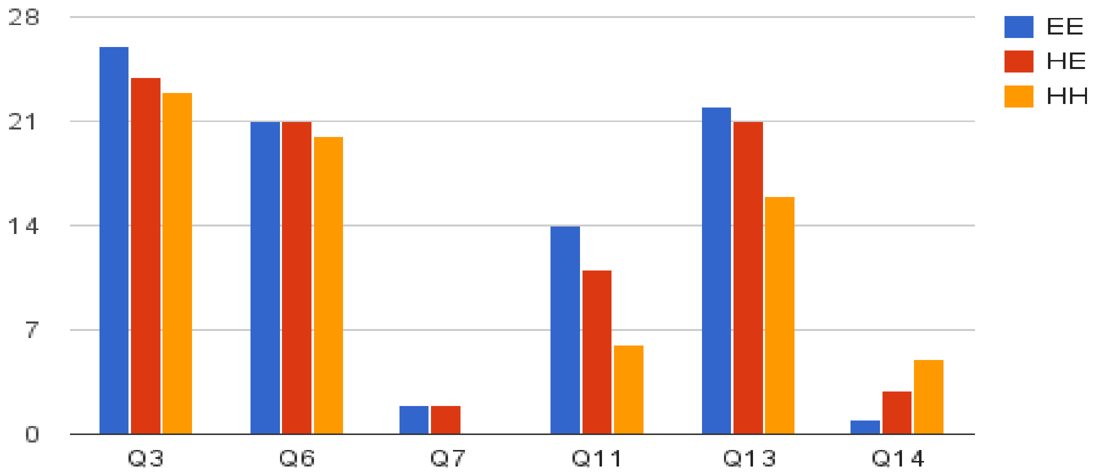


Figure 4.4 Performance in the apply level questions

4.3.3. Effect of self-reported prior knowledge

In order to see if there is a difference between the post-test score of sub-groups that have prior-knowledge (PK) of programming, we determined the means for various sub-groups as given in Table 4.9.

Table 4.9 Means of sub-groups

Students	**Stats.**	**EE**	**HE**	**HH**
Total Students	No. of students Mean score	31 5.90	31 5.52	31 4.77
Has prior knowledge of programming	No. of students Mean score	16 6.63	12 5.42	5 5.20
No prior knowledge of Programming	No. of students Mean score	15 5.13	19 5.58	26 4.69

Although the prior-knowledge is self-reported and not determined through a pre-test, we found that it plays a role when the MoI of K-12 and our treatment are matched (EE and HH groups), with mean scores for EE being greater than HH. To delve further, we carried out pair-wise paired sample t-test between the sub-groups within each group. We found there is no difference between the sub-groups for any group at 0.05 significance level.

To investigate further, we plotted the interaction effect between MoI and self-reported prior knowledge for Hindi medium (HE and HH groups), which is shown in Figure 4.5.

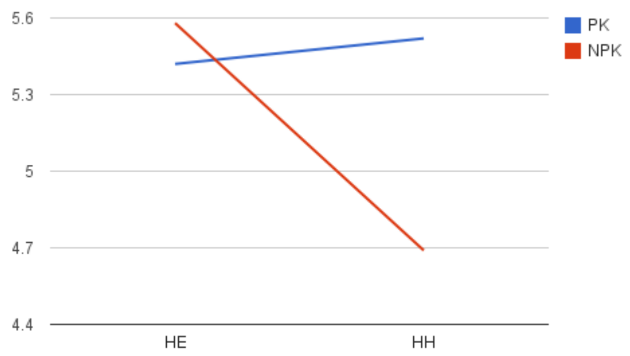


Figure 4.5 Interaction plot of prior-knowledge with MoI for Hindi medium

Since there appears to be interaction between the factors, we carried out a factorial analysis of variance using ANOVA but did not find them to be significant Table 4.10. This indicates that self-reported prior knowledge has no significant impact on the performance of students in post-test scores.

Table 4.10 Factorial analysis of variance using ANOVA

Source	**Df**	**SSQ**	**MS**	**F**	**P**
MoI	1	3.25	3.25	0.80	0.38
PK	1	0.32	0.32	0.08	0.78
MoI x PK	1	1.20	1.20	0.29	0.59
Error	58	235.89	4.07		
Total	61	240.66			

Our treatment of teaching introductory programming using classroom recorded video lectures in English MoI versus Hindi MoI, did not result in any significant difference between post-test scores of experimental, control and baseline groups. One reason for the lack of difference could be that the mean scores are consistently low for all three groups.

4.4.Problem resolution phase

In this phase of this research cycle (RC1) we try to identify the possible cause of problems and decides the actions for second research cycle (RC2). As we see that the post-test scores of all groups was low and the effectiveness of the videos used for this study was not calculated before this study. We can now say that the videos used in this study are not effective for the treatment provided in this research cycle. We also found that the problem was also possible in other components of the intervention used in this RC. These possible problems in the intervention are listed below.

- **Treatment:** All students was watching the video running on a projector for continuously 3 hour with a 15 minute break after every 1 hour. One possible reason is this treatment itself as it is difficult for students to be actively engaged while watching three consecutive 1-hour lecture videos, even with breaks. Despite our earlier reasons for using classroom recorded videos, we have reconfirmed that long classroom recorded videos should be avoided. So, for next research cycle, we need to look for a different solution that satisfies our constraints. Moreover, all the students had to watch the video simultaneously, without any scope for watching at their own pace. Hence the actual learning for any group, as measured by post-test scores, was low.

- **Instrument:** The post-test given to students contains total 14 questions of knowledge and apply level. This assessment instrument was not standardized, the questions was based on the standard textbooks of computer programming. Students were given total 30 minutes to solve the test that counts to 2 minutes for each question. Although our post-test was based on questions from the university exams and the standard textbook, it is possible that they were difficult for the students, either at a conceptual level or with respect to the time limit (2 minutes per question).

- **Topic:** The videos were on the topics: (1) Introduction to Computers, (2) Introduction to Cpp, and (3) Numerical Computing. These topics cover very few programming constructs as the topics chosen were of introductory nature, so it is possible that the corresponding learning objectives and questions are not much influenced by MoI. This possible problem set the requirement standard curricula with many programming construct for next research cycle.

- **Subject:** Computer programming is inherently an application-oriented skill and needs laboratory / tutorials. So a treatment of only watching lecture videos may not be appropriate for this topic, leading to low scores for all the groups. This possibility needs to be confirmed from the literature before designing the next prototype.

4.4.1. Impact of scaffoldings on learning

We found that the problems in the choice of treatment, topic, subject and instrument leads to poor performance of students. Because of these problems, Effect of scaffolds used in this research cycle did not show any impact. So, we decided to use same scaffolds in next research cycle after solving the problems found in this research cycle.

4.5. Summary[2]

In this research cycle we did not see any impact of MoI as there was no significant difference in post test scores of all groups. We found that classroom recorded video tutorials are not effective and should not be used for further research cycles. Video based learning is not effective in general classroom environment where students have no control over pace. We also found that MoI is not the only problem that hinders learning possible problem was in treatment, content, topics or assessment in this research cycle. So, generalizing our results to conclude that providing classroom recorded videos in Hindi MoI to Hindi medium learners is ineffective, is also not correct. More experiments or literature review are required in order to determine: (i) the type of topics as well as the duration of the videos for which such treatment could be effective, and (ii) type of treatment for programming and duration that would be effective for local language learners. The summary of this research cycle is presented in Table 4.11, that shows the assumptions, actions and findings of this research cycle, actions for next research cycle, and guidelines for further research cycles. The problems of this RC is addressed in next research cycle (RC2) that is described in Chapter 5.

[2] The findings of this research cycle is published in an international conference (Pal & Iyer, 2012).

Table 4.11 Summary of first research cycle

Assumptions	Actions	Findings	Actions for next RC	Recommendation for guidelines
Teaching in Hindi MoI will improve performance in post-test	Hindi MoI is used to teach computer programming.	MoI didn't show any significant difference in post test scores.	Use Hindi MoI as the effect of MoI was not visible in this reserch cycle.	
Use of classroom recorded videos will be effective to students	Classroom recorded video tutorials are used.	Classroom recorded video tutorials are not effective.	Use educational videos, created specially for teaching/learning.	Don't use classroom recorded videos.
Using videos in classroom environment where all students are watching it together will result in improved performace.	Videos were played on a projector and all students were watching the same video at a time.	Video based learning is not effective in general classroom environment where students have no control over pace.	Students should be able to watch videos on their own pace.	Videos should be used only in 1:1 self-paced environments
		Possible problem was in treatment, content, topics or assessment.	Solve problems in treatment, content, topics and assessment before measuring the effect of MoI on learning.	
		MoI is not the only problem that hinders learning.		

Chapter 5

Research Cycle 2: Short educational screencasts

In Chapter 4, details of first research cycle (RC1) are given in which we were trying to find the impact of the MoI on the programming abilities of learners from various mediums. We did not find any significant difference on post-test scores of various groups so we were unable to find any difference of MoI on learning. This chapter presents the details of second research cycle (RC2) which was carried out to resolve the problems of first research cycle reported in Section 4.4.

In RC1, we had conducted a quantitative study. The study had not shown any significant difference in post-test scores of all groups. We did not get any insights from students about the problems they faced during the intervention and possible solutions. Hence, we decided to conduct a qualitative study after solving the problems of previous intervention. This research cycle presents the qualitative study conducted to identify the problems of vernacular medium students during self-study from video tutorials.

In this research cycle, we changed the mode of instruction as suggested by literature. We also changed the learning material and selected standard topics of programming. Difference between RC1 and RC2 is presented in Table 5.1.

In RC1, we found that classroom recorded video tutorials are not effective when learners cannot watch them at their pace. We conducted a literature review on use of videos in education (Section 2.5.3). For this research cycle, we did not choose face to face classroom setting as vernacular medium students reported affective problems in the classroom settings (Section 2.2), while they did not complain about the same in a self-paced study. Based on the literature review on educational videos, we selected educational screencasts in both the MoI, Hindi and English. A screencast is a type of educational video that is created by recording the computer screen with the activities of computer screen (Guo et al., 2014). Screencasts are generally recorded with audio explanation using which an instructor can record oral explanation of the educational content being recorded. The main purpose of this research cycle was to locate shortcomings and usefulness of the educational screencasts, match with our prototype, to teach vernacular medium students. This is operationalized into the following specific questions:

RQ2.1: What is the expected and actual effectiveness of educational screencasts recorded in English MoI to teach programming to vernacular medium students?

RQ2.2: What is the expected and actual effectiveness of educational screencasts recorded in Hindi MoI to teach programming to vernacular medium students?

In this research cycle RC2, we selected educational screencasts that are developed especially to teach programming. We conducted a qualitative study with ten students and three teachers. Teachers were interviewed and their review of the videos was collected on a paper. Content analysis was performed on the data generated by teachers to measure the expected effectiveness of the screencasts. We divided ten students into two equal groups named HH and HE. HH group was watching Hindi screencasts and HE group was watching English screencasts. Students were asked to write question on a notepad, if they have any, and teacher will answer all the questions after the treatment. Students' interview was conducted after they finished watching screencasts. Content analysis was performed on the questions generated by students and their interview to measure the actual effectiveness of the screencast.

In section 5.1 we describe the need analysis phase where we try to resolve the problems of research cycle 1 (RC1) presented in Section 4.3. Design and develop prototype phase is presented in Section 5.2, in which we created the details of the second intervention and choose a research design to answer the research questions RQ2.1 and RQ2.2. Section 5.3 of this chapter describes the evaluation to measure the effectiveness of intervention. Section 5.4 presents the problem resolution phase where we discuss the learnings and findings of second research cycle (RC2).

5.1.Need analysis phase

In this phase of the research cycle (RC2) we try to resolve the problems of previous research cycle (RC1) by literature review. Problem resolution phase of previous research cycle (Section 4.4) gave input for the need analysis phase of this research cycle. From the previous research cycle we found that problems are possible in selection of subject, topic, treatment or instrument.

We conducted literature review to solve the problems of previous research cycle. Possible solutions of the problems of RC1 from literature review are listed below.

Subject: Programming is a difficult subject and failure rate of students in this subject is high (Mitra, 2010; Tollefson & Tsui, 2003), so we decided to stick to the computer programming subject.

Topics: We conducted literature review to find the topics list of computer programming and found ACM CS curricula 2013 (Section 2.5.4). We selected topics and corresponding learning objectives from it. Details of the literature review conducted for selection of computer programming topics is presented in Section 2.5.4.

Treatment: We also conducted a literature review on use of videos for education and found that long videos are not effective and educational videos need to be designed with appropriate video design principles. The literature review on educational videos is given in detail in Section 2.5.3.

Instrument: We did not use any post-test as the study conducted in this research cycle is qualitative. Instead we tried to identify the problems of vernacular medium students by interviewing teachers and students and collected data about the shortcomings and usefulness of the educational screencasts used in this research cycle.

Choice of subject, topic, treatment and instrument is given in Table 5.1 along with the differences for them in RC1 and RC2.

Table 5.1 Differences of intervention between RC1 and RC2

	RC1	RC2
Choice of subject	Computer programming	Computer Programming (Similar as previous)
Topics	Topics: the topics chosen in RC1 have very few programming constructs.	Topic chosen from a standard curricula with appropriate learning objectives and have many programming constructs.
Learning material	Classroom recorded video lectures.	Screencasts specially designed to teach programming in self-study environment.
Treatment	3 hour long treatment, with 15 minute break after every 1 hour, in a classroom environment where all students are watching same video presented through projector.	5 short videos of total 00:56:02 minutes long. Every student was watching the video on separate computer with his/her pace.

Table 5.2 presents the assumptions and corresponding actions of this research cycle. These assumptions were based on the findings of previous research cycle and literature review to solve the problems of first prototype, presented in Section 4.2.1 .

Table 5.2 Assumptions and actions of this research cycle.

Assumptions	**Actions**
Vernacular medium students will easily comprehend the learning content, if delivered in Hindi MoI	Use Hindi MoI to deliver educational content to identify the usefulness of Hindi MoI to teach vernacular medium students.
Teachers will report the usefulness of Hindi MoI in educational videos to teach vernacular medium students.	
Vernacular medium students will face difficulty in comprehending the learning content, if delivered in English MoI	Use English MoI to deliver educational content to identify the shortcomings of English MoI to teach vernacular medium students.
Teachers will report the shortcoming of the use of English MoI in educational screencasts to teach vernacular medium students.	
Educational videos created by following educational video principles will be useful for learning.	Screencasts, created by following educational video design principles are selected to teach programming.
	New videos were not created because we found videos that claimed to be satisfactory for the purpose.
1:1 self-paced study using educational videos will help to comprehend educational content.	Students were allowed to watch screencasts at their own pace. They were also allowed to use video player controls.
Systematic selection and presentation of topics will help in learning programming.	Topics were chosen from a standard CS curricula with appropriate learning objectives.
Vernacular medium students will not face affective problem in self-paced learning environment.	Self-paced learning environment is used.
	Face to face classroom teaching was not chosen as students reported affective problems in that.

5.2.Design and develop prototype phase

Based on the findings of previous research cycle and need analysis phase of this research cycle we decided to use small educational screencasts to teach computer programming topics selected from ACM CS curricula 2013. Table 5.3 represents the details of intervention of this research cycle.

Table 5.3 Details of intervention provided in RC2

Elements of intervention	**Details of second prototype**
Subject	Computer programming
Topic	Topics were chosen from ACM CS curricula, presented in Table 5.4.
Learning material	5 short length screencasts in both languages (total 10). Recorded specially to teach programming in self-paced mode.
Treatment	One hour workshop Self-paced environment

5.2.1. Second prototype: short educational screencast

Second intervention prototype: Use of short screencasts using either Hindi MoI or English MoI in a self-paced mode where student will watch the screencasts with his/her pace.

5.2.1.1. Selection of learning material

Content creation is a time consuming process and we were still unaware of two main questions to create educational screencasts. First, what problems do vernacular medium students face when learn from educational screencasts of English MoI. Second, How to handle various MoI in videos. So, we decided not to create screencasts but select the available screencasts that match with our prototype. We selected 5 video tutorials on introductory programming, created under a project of NME-ICT (National Mission in Education through Information and Communication Technology[3]), launched by the Ministry of Human Resources and Development, Government of India. These videos have seen positive impact on novice learners in a study conducted by the video tutorial creators (Eranki & Moudgalya, 2012). Video tutorials were chosen by mapping the topics and learning objectives from ACM CS curricula 2013. Video title, sequence number and its running time is given in the Table 5.4. Videos were given to the students in the ascending order of sequence number.

[3] http://mhrd.gov.in/technology-enabled-learning-0

Table 5.4 Video tutorials for second prototype

Seq. no.	Video title	Running time (MM:SS)
1	First C Program	11:57
2	Tokens	13:40
3	Functions	09:59
4	Scope of variables	08:09
5	If and Else-If statement	12:27

Videos were available in both languages English and Hindi and completely identical in terms of the content presentation and explanation. Slides and source-code in both videos were written in English and difference was only in oral explanation. Learning objectives of the videos chosen for the study was similar to the learning objectives recommended by ACM CS curricula. Learning objectives of the screencasts selected for this study are given in Table 5.5.

Table 5.5 Learning objectives of screencasts for second prototype

LO number	Learning Objective
LO1	Analyze and explain the behavior of simple programs involving the fundamental programming constructs.
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.

5.2.2. Scaffoldings used in second prototype

In this section we present the details of scaffoldings used in second research cycle. We provide two types of scaffoldings in this research cycle: 1) language-based scaffold, 2) affective scaffold.

5.2.3. Language-based scaffold

We used two types of educational screencasts in this research cycle 1) vocal explanations in English MoI and 2) vocal explanation in Hindi MoI. Language-based scaffolding in both types of screencasts is different.

Language based scaffolds in Hindi screencast

The reason to use Hindi MoI (Table 5.6, point 1) is same as previous research cycle. In previous research cycle we did not see its impact on learning because of other problems. Hence, we decided to use it again after solving the problems of previous research cycle.

One new scaffold, translate specialized words in vocal explanation (Table 5.6, point 2), was introduced in this research cycle to test its impact on students' performance. Specialized terms like, compile, execute and others are translated in their corresponding Hindi words and used in vocal explanation.

Table 5.6 language-based scaffold used in Hindi screencast

No.	Detail of scaffolding in Hindi screencast	Where to use
1	Use Hindi MoI	Vocal explanation
2	Translate specialized words	Vocal explanation

Language based scaffold in English screencast

Use simple English MoI in vocal explanation and on-screen text is used again. We were unable to find the effectiveness of this scaffold in previous research cycle because of the problems in other elements of intervention used in RC1.

One new scaffold, use slow pace for vocal explanation (Table 5.7, point 2) is used in the prototype designed in this research cycle. This scaffold is identified from literature (Section 2.5.2) where teachers reported to use secondary language for vocal explanation with slow pace to support vernacular medium students.

Table 5.7 language based scaffold used in English screencast

No.	Detail of scaffolding in English screencast	Where to use
1	Use simple English MoI	Vocal explanation, on-screen text
2	Use slow pace for vocal explanation	Vocal explanation

Affective scaffold

Students reported that they did not face affective problems in self-study environment. Because of the affective problems students do not ask teacher to repeat even if they miss something in classroom. In a study conducted by Simpson (Simpson, 2006), students reported that the controls of video player acted as scaffold for them. When they do not understand something, they go back and watch it again (Section 2.5.3). We are using term affective scaffolds for the support that is solving the affective problems of student. Affective scaffold was provided using self-paced screencast based learning environment (Table 5.8) to both the groups.

Table 5.8 affective scaffold used in second prototype

No.	Detail of affective scaffold
1	Screencast based self-paced learning environment

5.2.4. Research Design

We selected learning material to teach programming for screencast based self-paced learning environment. The screencasts chosen for the study was in both MoI, Hindi and English. We chose three teachers, teaching computer programming in current semester, from three different reputed engineering colleges and did focus group to test expected effectiveness. We then performed content analysis on the data generated by teachers. We did a micro-evaluation with the students to test the actual effectiveness of the prototype. There were two goals to do a micro-evaluation, one, to confirm the results obtained from the expected effectiveness evaluation and second, to gain new insights on shortcomings and usefulness of selected educational screencasts.

5.2.4.1. Sample

The sample of focus group consisted of three computer programming teachers of first year engineering from a college of North India.

The sample size of micro-evaluation was ten undergraduate vernacular medium students. We included only those learners who were 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. The sample was divided into two groups named HE and HH based on the MoI of the learning material provided to them as shown in Table 5.9.

Table 5.9 Group details to measure the effectiveness of second prototype

Name of group	Prior MoI	MoI of videos	No. of students
HH	Hindi	Hindi	5
HE	Hindi	English	5

5.2.4.2. Instruments and Data Collection

To measure expected effectiveness of the learning material, teacher's views on the learning material was collected using focus group (expert appraisal) method. We used 3-item survey to collect data about the expected effectiveness of the learning material. The items of the survey were: 1) why will you accept these videos to teach programming to teach vernacular medium students? 2) why will you not accept these videos to teach programming to vernacular medium students? and 3) what will be your final judgment on using the videos to teach vernacular medium students? At the end, we also interviewed teachers to get more insights on the problems and possible solutions in the educational screencasts.

To measure actual effectiveness of the learning material, student's interview and questions about content were collected using micro-evaluation method. 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.

5.2.4.3. Procedure

Measuring Expected effectiveness:

Survey: We first conducted a survey in various engineering colleges and selected only those teachers who had experience in teaching computer programming to undergraduate vernacular medium students.

Arrangement: All teachers separately participated in the activity. Teachers were watching videos on a computer in a pre-defined sequence and filling 3-item survey to record their views on learning material. The computer was equipped with headphone.

Treatment: Video tutorials chosen for the study was given to teacher with the 3-item survey form. After completing this activity teachers were interviewed on how the problems in the learning content could be solved.

Measuring Actual effectiveness:

Survey: We first conducted the survey and selected only vernacular medium students based on the medium of their 12th standard study. 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. Among all students we selected only ten students for the study.

Arrangement: All students were given a separate computer with a headphone. Students were allowed to watch the videos in the fixed sequence decided by the researcher. Total video length of 5 videos was 56 minutes 2 seconds. Each student was given a notebook with pen to make notes and write questions. Students of HH group were watching Hindi MoI screencasts while students of HE group was watching English MoI screencast.

Treatment: Students were watching videos on their own pace. Students were asked to write the questions on a paper if they had any in the paper and teacher will answer them after they finished watching all the videos. There was no time limit, students were free to watch videos as long as they wanted. There were no additional tutorials or laboratory exercises. The topics and learning objective of the topics are listed in Table 2.5 and Table 2.6 respectively. Each student was free to use video player controls according to the need.

5.3. Evaluation of short educational screencast

5.3.1. Content analysis

Expected effectiveness

To measure expected effectiveness, we transcribed and analysed the data collected from teachers using content analysis (Krippendorff, 2012). The data was collected in written form, using a 3-iterm survey for each video, and in audio, recorded during interview. The response were initially coded along 5 categories 1) problems because of Hindi MoI, 2) benefits because of Hindi MoI, 3) benefits because of English MoI, 4) problems because of English MoI and 5) solution of language based problems. However three categories namely, instructional design, choice of environment / tool and presentation style emerged from the teachers' responses. Within each category we initially coded teachers description of the shortcoming and goodness of the method used in the video. The codes describing non-unique/overlapping behaviours were then merged. The final list of codes along with their category is given in Table 5.10.

Table 5.10 Category and codes emerged from content analysis of teachers' perception on screencasts

Category	Code
Problems because of English MoI	• Understanding content
Benefits because of English MoI	• Improvement in English
Problems because of Hindi MoI	• Use of complex vocabulary • Unable to write assessment and exams
Benefits because of Hindi MoI	• Understanding content
Possible solutions of language based problems	• Subject specific words • Maintain consistency • Use of simple English language • Translation or transliteration
Instructional design	• Use of more than one programming languages • More content required (example / information) • Less content required (examples in multiple programming language) • Instructional gap • Live-coding • Syntax writing • Content sequencing
Choice of environment/tool	• Selection of operating system (Windows / Linux) • Use of programming environment (GEdit / IDE) • Use of terminal / GUI
Presentation style	• Use of animation • Monotonous presentation • Use of diagrams (flow chart) • Loss of attention • Interesting content (example) • Similar presentation (all videos looks like same) • Quality of voice • Video length

The results of the content analysis in each category are observed from teacher's interview and survey text. The result of the content analysis is summarized in Table 5.11. From the results, we note that teachers believed that students will not face any problem in learning programming because of English MoI as the language used in screencasts is simple. They also believed that use of simple English MoI will improve the English competency of students that will help them to write assessments and exams in English. Teachers reported problems in Hindi MoI and believed that students will not be able to understand rarely used Hindi words. Use of Hindi MoI will not help in building English competency that will result in poor performance in exams, teachers believed this. Teachers reported problems in instructional design, choice of environment or tools and presentation style and believed that problems in these will hinder the students learning of programming. Content analysis of teachers comments are grouped in three groups.

1. **Language based believes**

Use of simple language in selected tutorials will not only help in learning content but also help in developing English competency. Improved English competency will help in writing exams and assessment. Teachers believed that students will not face any problem in learning from chosen English MoI screencasts. In general they believed that use of complex English MoI in screencasts will not help in learning programming.

Teachers reported that Hindi vocabulary of Hindi MoI screencasts is very complex. Few Hindi words used in screencasts are not used in normal conversation, this will make it difficult for students to learn from the screencasts. The translation of subject specific words in Hindi and using them across all screencasts will not develop his/her English competency and student will poorly perform in final Examination. Use of subject specific words in screencasts are not consistent, switching between translation and transliteration will create difficulty in comprehending the learning content.

2. **Instructional design believes**

Teachers were not satisfied with the way the instructional content was designed. Teachers reported problems in use of more than one programming languages, instructional gap and content sequencing. Analysis of teachers generated text highlighted shortcomings and goodness in the way programming language was taught, non-use of live coding and syntax writing.

All teachers believed that use of two languages in teaching programming first time will create more load on student as he/she needs to remember more syntax and keywords to make sense of the program presented in screencast. Switching between two languages for one problem or concept is not helping in learning educational content. Using two languages and presenting one example in two languages is increasing the length of screencasts. Few statements of teachers showing their concern of using two languages to teach programming are given below-

- “The change from c to c++ can be confusing to novice learners.”
- “The change in (programming) language would have been little confusing.”
- “... changes are done in almost 80% of the program hence each step must be defined separately.”
- “... changing header file name, replacing %d, %f etc. to << and all other changes must be explained...”

Teachers reported many instructional gaps such content being taught without covering all prerequisites in the screencasts. Teachers believed that the presence of instructional gap would reduce the effectiveness of the screencasts. Teachers reported that instructions related to terminal, Linux, data types, constants, arguments, pointer type and memory address should also be part of chosen screencasts to complete the instructions. Few statements related to instructional gaps are given below-

- “What is terminal window? Not mentioned.”
- “Why the OS is linux not explained.”
- “Data types, constants etc. should be explained too to make sure that learner is not stuck at a point.”
- “The tutor did not explain terms like arguments, pointer type, and memory address and so on while defining the types of function calls”
- “Tutor should have explained other control statements like while loop and so on.”
- “compile statement is not explained properly.”

- “variable assignment and declaration must defined separately...”
- “Data types are not defined properly...”
- “variables, data types, keywords etc.?”
- “why we use double instead of float & why long instead of int etc...”
- “...every statement must be elaborated in detail ...”
- “function calling must be explained ...”
- “why the changes are made into the initial function .... must be explain”
- “not explained the global and local variable.”
- “main() is not explained neither return type of main().”

Teachers believed that use of more examples would have made the instructions presented in screencasts more effective. All teachers believed that while the short length of the screencasts helped in engaging the students, using few examples would result in poor learning. Few example related statements of teachers are written below-

- “Variations in error examples needed.”
- “Tutor should have given more variety of examples”

Teachers reported that the sequencing of content in screencasts is not appropriate, this will make learning from screencast difficult. The evidence of this can be seen in these statements-

- “The tutor should have explained the swap function prior to its use in the programme.”

One teacher reported that pre-written text will not attract students and suggested to use live-coding method instead. According to him - “It would be nice if the tutor had coded certain programs while explaining the concept instead of displaying ready-made block of code.”

3. Choice of environment / tools

All teachers reported that use of an operating system that is new to the students will create difficulty in learning. Use of Linux operating system in the screencast is not suggested by teachers. Teachers suggested that students have exposed to windows operating system either before coming to college or after they have come to college. Teachers did not neglect the importance of Linux operating system but they suggested to teach both separately or teach Linux before teaching programming.

Use of terminal and GEDIT to write, compile and run the program is making it difficult to focus on learning computer programming. Teachers believed that students will think that the program writing is a complex process and they will pay more attention to program development environment. Instead teachers suggested to use a GUI based IDE to keep students focus towards programming constructs.

- "Use of a windows platform would have looked interesting to me. Or at least use of a proper IDE."
- "Considering the present scenario where everybody uses systems that run Windows, the tutor should have specified why he/she chose Ubuntu over Windows to give a clear idea to the users learning from the tutorial."
- "Ubuntu is not generally used so it may create problem."
- "... importance of ubuntu also should be explained for a new user working on it."
- "… not explained each term already written in terminal, this may create confusion."
- "… not explained properly that talk.c (compile command) is the name of the file."

4. Presentation based believes

Teachers reported that the screencasts were monotonous in presentation and making it hard to keep listening to it. Use of flowcharts were appreciated in few screencasts and teachers recommended to use flowcharts or any other useful graphics in content to make it interesting. Use of animations at various places of screencasts was also suggested to make it more interesting and gain students attention. Teachers also suggested using interesting examples from students real-life to make the presentation interesting. Teacher's statements related to monotonicity of presentation and its possible solutions are given below-

- “Monotonous and boring presentation.”
- “No use of animations or multimedia resources.”
- “One of the main drawbacks is plain and monotonous.”
- “No use of multimedia hence loses attention.”
- “Use of Flow chart served better visualization.”
- “Definitions if had been presented in an animated fashion would have left a positive impression in the minds of the learner”
- “This tutorial is too monotonous making it very boring. “
- “No usage of animation or flow chart.”
- “This tutorial fails to keep its learner’s attention.”
- “The tutor could have used the flow chart (while teaching if-else statement) more effectively with an example rather than just depicting general statements.”

Teachers appreciated the fact that all screencasts follow the same slide design and presentation style.

Teachers were satisfied with the voice quality and pace of vocal explanation of the screencasts. Teachers believed that this pace, clear pronunciation and voice quality will help students in receiving English MoI and comprehending content presented in English MoI. Few statements of teachers about it are presented below -

- “The voice over is clear in pronunciation and simple and understandable use of language is also a plus point.”
- “Tutor has made use of simple and clear language hence the need for subtitles is not felt.”

Teachers find the length of screencasts satisfactory. They believed that short length will help in gaining students’ attention.

Expected effectiveness of the chosen screencasts was measured by teachers using focus group and interview. Findings are presented in Table 5.11 that lists usefulness and shortcomings with possible solutions suggested by teachers.

Table 5.11 Teacher's perception of screencasts and suggested solution to the problems

Teachers perception on the chosen screencasts	**Possible solutions suggested by teachers.**
Reason of acceptance of English Screencasts	
Use of easy verbal English MoI in English screencasts	
Slow pace of verbal English MoI in English screencasts	
Use of English MoI will improve English proficiency	
Students will be able to attempt exams and assessment given in English	
Reason of rejection of English screencasts	
	I would have rejected English screencasts if pace of screencast would be fast or complex English would be used.
Reason of acceptance of Hindi screencasts	
	I would have chosen Hindi screencasts if simple Hindi was used and subject-specific terms are used in English.
Reason of rejection of Hindi screencasts	**Solution suggested by teachers**
Choice of complex Hindi words in screencasts	Use Hindi words
Translation of subject specific words will limit English proficiency	Do not translate subject-specific words in Hindi
Inconsistency in using subject specific words in screencasts	Always use subject-specific words in English never switch between translation to transliteration

Students will not be able to write exams and assessment given in English	Teach learners in a way that they learn content with English language.
Instructional design problems	**Solution suggested by teacher**
Two programming languages are used in teaching programmig construct, this will confuse the novice learners	Use only one language, focus only on teaching programming construct, not two programming languages
Instructional gap in learning content	Systematically plan instructions.
Use of few examples in the screencasts will not clear the concepts	Use appropriate examples to teach every programming construct
Inappropriate content sequencing	Systematically plan instructions.
Choice of development environment / tool	**Solution suggested by teachers**
Linux operating system in not appropriate for novice learners	Either use windows or teach basic linux before teaching programming.
GEDIT to create and edit computer program is confusing	Use an IDE, as the focus is to teach programming not GEDIT or working on terminal.
Use of terminal and commands to compile and run program is not appropriate for first time learners	Use of terminal or command line should be taught separately.
Presentation style	**Solution suggested by teachers**
Monotonous presentations will not be able to gain students attention	Use flowcharts, animations, and graphics wherever required.
	Use interesting examples from student's real-life.

Teachers' expectations was related to use of MoI, instructional design, choice of tools to teach programming and presentation style of the content. We expected to receive comments only on use of various MoI in screencasts but most of the teachers comments were related to instructional design and choice of tools to teach programming. In order to check the accuracy of teacher's perception we measured actual effectiveness of the screencasts.

Measure actual effectiveness

To measure actual effectiveness, we transcribed and analysed student interviews and questions generated by them using content analysis (Krippendorff, 2012). The responses were initially coded based on the results of expected effectiveness. Categories of the codes are 1) problems because of English MoI, 2) benefits because of English MoI, 3) benefits because of Hindi MoI, 4) problems because of Hindi MoI, 5) instructional design, 6) choice of environment/tool and 7) presentation style. Within each category we initially coded student's description of the shortcoming and goodness of the method used in the video. The codes describing non-unique/overlapping behaviours were then merged. The final list of codes along with their category is given in Table 5.12 below.

Table 5.12 Categories and codes emerged from content analysis of students generated data

Category	**Code**
Problems because of English MoI	• Problem in comprehension • Problem in understanding words • Problem in understanding sentences • Affective problems
Benefits because of English MoI	• English will improve • Affective problems
Problems because of Hindi MoI	• Problems in understanding words • Translation or transliteration
Benefits because of Hindi MoI	• Understanding content • Affective problems
Instructional design	• More content required (example / information) • Content sequencing
Choice of environment/tool	• Selection of operating system (Windows / Linux) • Use of programming environment (Gedit / IDE) • Use of terminal / GUI
Presentation style	• Monotonous presentation • Loss of attention • Quality of voice

Vernacular medium students reported several problems in receiving educational content in English MoI. The problems were related to comprehending the meaning of English sentences because of the use of complex English words in sentences, For example students did not know the meaning of English word 'execute' hence, they were unable to understand sentences which are using ‘execute’ word. Students were not confident that the instructions they were comprehending in English MoI were similar to what instructor wanted to deliver.

Vernacular medium students accepted using English MoI in further screencasts as they believed that use of English MoI will help them building English competency that will help in writing exams in English. Students believed that if they knew the meaning of all words used in screencasts then they would be able to comprehend the English MoI easily as sentences used in screencast are short and simple.

Vernacular medium students reported several problems in receiving educational content in Hindi MoI. The problems were related to use of several English words in screencasts without telling their meaning like “initialize”, “format specifier”, “identifier”, “parameter” etc. Second problem was related to use of complex Hindi words in screencasts. Some Hindi words reported by students are “nishpaadit” (निष्पादित), “nirdisht” (निर्दिष्ट) and “saaraanshit” (सारांशित).

Vernacular medium students reported to keep using Hindi screencasts as they were sure that they were confident in comprehending instructions.

Students of both the groups asked many questions related to data type, return type, use of %d, <<, argument. These questions confirmed the expectation of teachers where they reported that screencasts have several instructional gaps. Even the questions were related to the content that was presented in screencasts like function, use of condition etc. This confirmed teachers’ expectation that improper explanation and less examples would make it difficult to understand educational content presented in screencasts.

Students reported problems about use of Linux, command, terminal and Gedit etc. Few questions asked by students related to development environment are given below-

- “Why Linux is used? Can we write program on Windows?”
- “What is $ in terminal and how to write it?”
- “How did teacher open GEDIT? Can we open it from start menu?”
- “What is –o when compiling program?”

Students reported that the presentations were not engaging because of which they are losing attention.

Actual effectiveness of the chosen screencasts was measured by students using micro-evaluation and interview. Findings are presented in Table 5.13 that lists usefulness and shortcomings that confirms or rejects teacher's expectation from screencasts.

Table 5.13 Actual effectiveness of selected screencasts

Students problems on the chosen screencasts
Reason of acceptance of English screencast
Pace of verbal English MoI in English screencasts is appropriate.
English will improve.
Reason of rejection of English screencasts
Difficult to understand English MoI from screencasts.
Not confident whether they are understanding correct or incorrect.
Unable to understand the meaning of some general English words.
Use of complex English words leading to non-understanding of English sentences.
Reason of acceptance of Hindi screencasts
Feeling confident that whatever they are understanding is correct.
Reason of rejection of Hindi screencasts
Choice of complex Hindi words in screencasts
Some words are used in English but its meaning is not explained.
Instructional design problems
Questions were asked about data types, argument, pointer, memory address etc.
Some constructs are not explained but told in very less time.
Choice of development environment / tool
Questions were asked for Linux, gedit and terminal.
Presentation style
Presentation is boring and difficult to maintain interest.

Actual effectiveness of screencasts was measured in use of MoI, instructional design, choice of tools to teach programming and presentation style of the content. We expected to see similarities in teacher's perception and actual effectiveness of the screencasts. Teacher's expectations were found to be true to instructional design, choice of tools to teach programming and presentation aspects of screencasts. Teacher's expectation that students will be able to comprehend the English MoI did not confirm when we measure actual effectiveness.

Students and teachers report of complex Hindi words in Hindi MoI and inconsistency in using subject-specific vocabulary leads us to analyse the transcript of screencast to identify these problems. Analysis of transcripts of one screencast is presented in next section.

5.3.2. Analysis of the transcripts of screencast

We analyse the transcript to identify the cause of student's problem in understanding the content from Hindi medium screencast. In Table 5.14 we present the analysis of first screencast named "first c program" used in this research cycle.

Table 5.14 Analysis of the content presented in screencast

Time	Narration	Analysis
00:13	इसे निष्पादित कैसे करें।	The word "निष्पादित" is a semi-specialized word. Its meaning in English is execute. निष्पादित is one of the words that is rarely used in spoken Hindi so most of the students did not know the meaning of this and same is true with the execute.
00:14	हम कुछ सामान्य एरर्स और उनके समाधानों को भी समझायेंगे।	The word एरर्स (Errors) is a general English word. Its Hindi meaning is "गलतियाँ" that is very commonly used by Hindi speakers. Instructor has transliterated the general English word while its Hindi meaning would be very easy for Hindi speakers.
01:56	यह प्रलेखन के लिए उपयोगी है।	"प्रलेखन" is a general word with the equivalent English meaning "documentation". In spoken Hindi "प्रलेखन" is a rarely used word and students do not know what does this mean. Hence, they reported problem for this word.
02:33	जब कोई प्रोग्राम स्टैंडर्ड इनपुट/आउटपुट फ़ंक्शन्स का उपयोग करता है, तो इसमें यह हेडर फ़ाइल (header file) अवश्य होनी चाहिए।	Instructor has used the subject-specialized term standard input/output functions. While student did not know its meaning as this was not explained in the tutorial before this and it is used in English.
02:52	यह व्यक्त करता है, कि प्रोग्राम का एक्जीक्यूशन इस लाइन से शुरू होता है।	Previously the word execute was translated by teacher in Hindi (निष्पादित) now in its second occurrence. It is pronounced as its transliteration "execution". This inconsistent use of vocabulary was confusing to students.

03:11	यहाँ int main function कोई arguments (आर्गुमेंट) नहीं लेता।	At this time neither student knew the meaning of argument nor it is present in main function. It was not necessary to tell this. This will unnecessarily confuse the student.
03:15	यह टाइप integer की वेल्यू देता है।	Integer is known as पूर्णांक in Hindi. This is a semi-specialized term as it is used in mathematics. Using "poornaank" will be more appropriate at this place. This statement itself is inappropriate to use here because instructor is telling that it returns value, but to whom is it returning the value is not clear. It will confuse student.
03:18	हम अन्य ट्यूटोरियल में data types (डेटा के प्रकार) के बारे में सीखेंगे।	Use of subject specific term "data-type" seems unnecessary here as it is never used in this tutorial before this point and this tutorial does not cover it.

We analysed all 5 screencast's transcript and found inconsistency in handling the subject specific, semi-specialized and general English terms in Hindi screencasts. Using a subject-specific word without appropriate context. Not explaining the subject specific term was also very common problem in the screencast.

5.4.Problem resolution phase

In this phase of this research cycle (RC2) we try to identify the possible cause of problems in the intervention and decide the actions for second research cycle (RC3). In the qualitative study presented in this research cycle we found that shortcomings in the screencasts are reported by teachers and students. Students did not report any shortcoming in treatment and the topics were chosen from standard curricula.

Treatment: Students need to watch five videos in a sequence decided by teacher. Total length of 5 videos were 56 minutes 2 seconds and there were no time limit, but most of the students finished watching videos in 1 hour 30 minutes. Neither teachers nor students gave any negative comment on the length of the screencasts or treatment in this study. Hence, we decided to use similar treatment for next research cycle.

The shortcomings reported by teachers and students in screencasts are summarized below that help us to take decisions for next cycle.

5.4.1. Shortcoming in screencasts

The shortcomings reported by students and teachers in this qualitative study can be categorized into four categories: 1) Problems related to the use of MoI, 2) Instructional design problem, 3) Choice of development tools, 4) Content presentation problems. Details of these categories are given below.

5.4.1.1. Problems related to the use of MoI

During the research design we were expecting students to report problem in use of English MoI only. We did not expect any problem in Hindi MoI but results was different as teachers did not report any problem in use of English MoI in screencasts but students reported several problems in use of English MoI as well as Hindi MoI. These language related problems can be divided into 1) use of general words, 2) use of subject-specific words.

Use of subject-specific words in screencasts

Students of both groups, HH and HE, complained about the understanding of subject-specific words as they did not know their meaning. Students who were watching screencasts with English MoI asked questions related to some subject-specific words as they did not know their meaning and having problem in comprehending the presented material. When we analysed the screencasts we found that subject-specific words like “initializer”, “format-specifier”, and “identifier” are being used in screencasts but their meaning was never explained. This finding helped us to decide in explaining the subject-specific term before using it in screencast for next prototype.

Hindi medium students found some Hindi words difficult to comprehend as they listened to those words for the first time and were unaware of their meaning. Some reported Hindi words are “nishpaadit” (निष्पादित), “nirdisht” (निर्दिष्ट) and “saaraanshit” (सारांशित). These words are not commonly used words in Hindi and these words are translation of subject-specific English words. This gives us clue to use subject-specific words in English MoI only for both students.

Inconsistency in use of these subject-specific words in screencasts with Hindi MoI are also reported. Analysis of Hindi screencast shows that sometimes these words were translated into corresponding Hindi words or sometimes these words were pronounced as the transliteration. This inconsistency of using subject-specific terms was creating problem to comprehend the presented material. In the next research cycle the rule about use of translation or transliteration should be fixed to maintain the consistency.

These findings helped us to decide how to use these subject-specific words in next research cycle. As the meaning of subject-specific terms in unknown to both Hindi medium students and English medium students and they will learn about a subject-specific term first time from the screencast. In addition we want the student to make proficient in English. So, we decided not to translate subject-specific words for Hindi medium students.

Use of general words in screencasts

Hindi medium students watching screencasts using Hindi MoI reported that some Hindi words were unknown to them and they heard them for the first time. For example "प्रलेखन" is a general Hindi term that means "documentation" in English. We decided to either use simple Hindi meaning of general words or simple English meaning of the word in next prototype.

5.4.1.2. Instructional design problem

Analysis of the transcript is presented in Section 5.3.1 of this chapter. We found that instructional content was not appropriate for vernacular medium students and needs improvement. This finding helped us to conduct literature review on design of the instructional material. Literature review conducted to identify the principles of content development help us in developing next prototype.

Questions generated by students indicated instructional gap (missing information) in the videos. We used the term instructional-gap when a new content was delivered without fulfilling its pre-requisites. There were some pre-requisites to learn the material presented in the videos but prerequisites are neither mentioned nor covered in the videos. We chose videos in the sequence recommended from the project's website but there was instructional gap between two consecutive videos too. This problem needs to be resolved in further research cycles by investigating literature.

5.4.1.3. Choice of development tools to teach programming

Teachers reported the shortcomings of use of Linux operating system and terminal to teach programming to novice learners. In micro-evaluation method we found that students asked questions related to GEDIT, terminal and Linux. Our main objective is to teach programming to students, thus we decided to implement teacher’s suggestions for next prototype, i.e. the use of Windows operating system and an IDE.

5.4.1.4. Content presentation problems

Teachers reported the problem in content presentation. They suggested using flow charts and other multimedia items to make the presentation interesting. Students also complained about monotony of the videos but they were unable to provide any suggestion for improvement. So, for the next research cycle we decided to conduct literature review on the use of multimedia in educational content.

5.4.2. Impact of scaffolding on learning

As presented in Section 5.4.1.1, students find it difficult to understand translated specialized words as these words are also new to them. This finding help us to drop this scaffold and we did not used this in next research cycles.

Slow pace for vocal explanation and screencast based self-paced learning environment was appreciated by students but because of other problems in screencasts (Section 5.4.1) students were unable to say whether these scaffolds have impact on their learning or not. So, we decided to use all scaffolds used in this research cycle, except ‘translate specialized word’, in next research cycle.

5.5. Summary

In this research cycle (RC2) we found several problems in use of Hindi MoI and use of English MoI in selected screencasts. These problems in use of MoI were reported not only by teachers but also by Hindi medium students. Some of these problems are use of translation of subject-specific terms in Hindi screencasts, use of complex Hindi words in Hindi screencasts, and not explaining the meaning of the subject-specific words in screencasts. Vernacular medium students reported some problem in use of Hindi MoI in screencasts and suggested to use simple English words for subject-specific words. Their suggestion of using two languages in instructional material lead us to conduct literature review on bilingual education to find how to handle subject-specific and general terms.

Apart from the problems related to MoI we found that inappropriate sequencing, chunking of instructional material and instructional gap create problems to students. This creates a need to use instructional design principles to systematically plan instructional material in next research cycle. Problems related to content presentation created a need to identify the multimedia principles of content presentation that will help vernacular medium students.

Use of screencast in self-paced study environment was reported to be beneficial for learning by students and teachers. Vernacular medium students reported no affective problem from screencast based self-paced learning.

The summary of this research cycle is presented in Table 5.15 that shows the assumptions, actions and findings of this research cycle, actions for next research cycle, and guidelines for further research cycles. The problems of this RC is addressed in next research cycle (RC3) that is described in chapter 6.

Table 5.15 Summary of second research cycle

Assumptions	**Actions**	**Findings**	**Actions for next RC**	**Recommendation for guidelines**
Vernacular medium students will easily comprehend the learning content, if delivered in Hindi MoI	Use Hindi MoI to deliver educational content to identify the usefulness of Hindi MoI to teach vernacular medium students.	Vernacular medium students reported several problems while learning in Hindi MoI.	Resolve the problems in Hindi MoI reported by students and teachers.	
Teachers will report that the usefulness of Hindi MoI in educational videos to teach vernacular medium students		Teachers reported problems in the way Hindi MoI is used in screencasts.		
		Translation of subject-specific terms reported as a problem by both teachers and students.	Conduct literature review on using subject-specific terms in bilingual education.	Do not translate subject specific terms.
		Students reported that use of complex Hindi words were creating problem in comprehending the content.	Use general Hindi terms in educational content, as suggested by students.	Use general Hindi words while using Hindi MoI in teaching educational content.

Vernacular medium students will face difficulty in comprehending the learning content, if delivered in English MoI	Use English MoI to deliver educational content to identify the shortcomings of English MoI to teach vernacular medium students.	Vernacular medium students reported several problems while learning in English MoI.		
Teachers will report the shortcomings of English MoI in educational videos to teach vernacular medium students.		Teachers reported usefulness of English MoI in teaching vernacular medium students.	Conduct literature review on using English MoI in teaching vernacular medium students.	
Educational videos created by following educational video principles will be useful for learning.	Screencasts, created by following educational video design principles are selected to teach programming.	Several problems at content and presentation level are reported in screencasts. These problems are hindering the effectiveness of videos on learning.	Conduct literature review on teaching educational content and educational content presentation.	
	New videos were not created because we found videos that claimed to be satisfactory for the			

	purpose.			
1:1 self-paced study using educational videos will help in comprehend educational content.	Students were allowed to watch screencasts on their own pace. They were also allowed to use video player controls.	1:1 self-paced study environment was reported to be beneficial for learning by students and teachers.		Use 1:1 self paced study environment for vernacular medium students as it supports learning.
Systematic selection and presentation of topics will help in learning programming.	Topics were chosen from a standard CS curricula with appropriate learning objectives.	Even though topics from standard curricula were choose, Instructional gaps in educational content reported to be a problem in learning.	Re design the material and remove all instructional gap.	Instructional gap creates problem in learning.
		In appropriate content sequencing and chunking led to problems such as, students were unable to make connections.	Conduct literature review on instructional design principles for appropriate chunking and sequencing of educational content.	

		Content presentation led to problems for students learning. Such as monotonous, attention cueing, split-attention.	Conduct literature review on multimedia principles of educational content presentation.	
Vernacular medium students will not face affective problem in self-paced learning environment.	self-paced learning environment is used.	Vernacular medium students reported no affective problem from videos based self-paced learning.		Use self-paced study environment to reduce affective problems in vernacular medium students,
	Face to face classroom teaching was not chosen as students reported affective problems in that.			

2

Chapter 6

Research Cycle 3: Primary language screencasts

In Chapter 5 details of second research cycle (RC2) is given in which we were trying to identify the expected and actual effectiveness of the screencasts used to teach vernacular medium students. We found that students were facing difficulty in learning not only because of MoI but also because of instructional gap, inappropriate content sequence, and improper use of development tools to teach programming and inappropriate use of English and Hindi vocabulary. This chapter presents the details of third research cycle (RC3) which was carried out to resolve the problems of second research cycle reported in Section 5.4.

In previous research cycle (RC2) we found few shortcomings in educational screencasts. These shortcomings are categorized into four categories 1) Use of English and Hindi vocabulary, 2) Teaching educational content, 3) Choice of development tools to teach programming and 4) Content presentation. We conducted a literature review to identify why shortcomings, other than MoI, are reducing the effectiveness of the educational screencasts in teaching vernacular medium students. We found that these shortcomings lead to increased cognitive load of vernacular medium students. Increased cognitive load reduced the chance to comprehend the presented educational material.

We conducted literature review on teaching various educational content (Section 2.5.6.1) and multimedia principles (Section 2.5.6.2) to reduce the cognitive load of students and reduce the shortcomings of screencasts, found in RC2. Literature review on instructional design, teaching educational content and multimedia principles to present educational content helped us to plan, develop and present the learning material respectively.

We created educational screencasts to minimize the cognitive load of vernacular medium students. These screencasts were created by following visualization guidelines of teaching educational content and multimedia principles. We created screencast only in Hindi MoI. The subject-specific vocabulary was used with transliteration, as suggested in literature. The main purpose of this research cycle was to identify the shortcomings and usefulness of educational screencast, recorded to minimize the cognitive load of the student. We named this type of screencast, cognitively scaffolded screencast.

We measured the effectiveness of cognitively scaffolded screencast on vernacular medium students. In this research cycle we created few small screencasts and evaluated them by micro-evaluation method as suggested by EDR because content creation is a time consuming process and we were still unaware of two main questions to create complete set of screencasts. First, what problems do vernacular medium students face when learn from cognitively effective educational screencasts. Second, what problems do vernacular medium students face because of language based intervention used in this prototype. These two questions are operationalized into the following specific questions:

RQ3.1: What is the actual effectiveness of using transliteration of subject-specific terms in Hindi MoI screencasts to teach computer programming to vernacular medium students?

RQ3.2: What is the actual effectiveness of Hindi MoI screencasts, planned using instructional design principles, to teach vernacular medium students to teach computer programming?

RQ3.3: What is the actual effectiveness of Hindi MoI screencasts, created using visualization guidelines of educational content types, to teach vernacular medium students computer programming?

RQ3.4: What is the actual effectiveness of Hindi MoI screencasts, created using multimedia principles, to teach vernacular medium students computer programming?

RQ3.5: What is the actual effectiveness of educational screencasts recorded in Hindi MoI to teach vernacular medium students?

In this research cycle (RC3), the mode of delivery of instruction was similar to previous RC (RC2), i.e. self-paced through screencasts. We redesigned the learning material based on the findings of literature review to reduce cognitive load. Topics were similar to previous RC, but reduced to match the timing of the treatment.

In section 6.1 we describe the need analysis phase where we try to resolve the problems of research cycle 2 (RC2), presented in Section 5.4. Design and develop prototype phase is presented in Section 6.2, in which we choose a research design to answer the RQ3.1 to RQ3.5 and details of intervention provided to students. Section 6.3 of this chapter describes the evaluation methods used to measure the actual effectiveness of intervention. Section 6.4 of this chapter presents the problem resolution phase where we discuss the learnings and findings of this research cycle (RC3).

6.1.Need analysis phase

In this phase of this research cycle we try to resolve the problems of previous research cycle (Chapter 5) by literature review. From the previous research cycle we found that vernacular medium students need scaffold in the screencasts at content level. From the literature review presented in Section 2.5.6 and Section 2.5.6.2, we found that cognitive load can be reduced by making improvement in educational content by integrating best-practices to teach computer programming, using instructional design principles, using visualization guidelines and multimedia principles to develop and present educational content. Language based scaffolding can be provided by appropriate use of MoI in the screencast.

Literature review conducted on best-practices on teaching computer programming is presented in Section 2.5.4 in detail. We also conducted a literature review on teaching various educational content to reduce cognitive load. We found that attention-cueing (use of an indicator to draw students attention on particular portion of screencast), is an effective technique when there are many elements in the presentation. Similarly use of reducing redundant information, segmentation technique and split-attention principles help in content presentation that reduce cognitive load. Based on the learning from the literature review, we develop next learning material in design and develop prototype phase presented in Section 6.2. Assumptions and actions of this research cycle are presented in Table 6.1.

Table 6.1 Assumptions and actions of third research cycle

Assumptions	**Actions**
Students will report the usefulness of transliteration of subject specific-terms in Hindi MoI screencasts.	Transliteration of subject-specific terms are used in written form of educational content.
Use of general Hindi terms used in normal conversation to deliver the educational content in Hindi MoI will make it easy for vernacular medium students to comprehend it.	Vocabulary of general spoken Hindi is used in the creation of educational content.
Verbal explanations of educational content in Hindi MoI will help in comprehension of educational content.	
Educational content created by following instructional design principles will have no instructional gap and sequencing and chunking will be appropriate.	Content is planned using instructional design principles.
Students will not report shortcomings indicating instructional gap and content sequencing in educational content if it is created by following instructional design principles.	
Educational content created by following "visualization guidelines to teach educational content" will help in selection and creation of appropriate examples, analogies and learning material.	Content was designed by following the "visualization guidelines to teach educational content types".
Students will not report shortcomings in selection of examples, analogies and learning material.	
Educational content presented by following multimedia principles will not be monotonous for the students.	Educational content was presented using multimedia principles.
Students will not report shortcomings in content presentation if learning content is presented using multimedia principles.	

6.2.Design and develop prototype phase

From the need analysis phase presented in Section 6.1 we found that improvements in the videos are possible at use of vocabulary,

6.2.1. Use of vocabulary in Hindi MoI

There are three kinds of vocabulary namely specialized, semi-specialized and general. Each needs to be handled in a different way to teach vernacular medium students. These three vocabularies are defined below-

Specialized vocabulary: Specialized vocabulary consists of all the words unique to the subject. For example, compiler, header file, pre-processor, return type etc. are unique to programming only.

Semi-specialized vocabulary: semi-specialized vocabulary usually has meaning in everyday life, but has another meaning in subject. For example, "program" means a planned series, while in computer programming this means "set of instructions".

General vocabulary: All words other than semi-professional and specialized vocabulary.

All terms that belong to semi-specialized or specialized vocabulary are explained in detail on their first occurrence. These words are not translated but their transliteration is used in written and spoken forms. This satisfies one goal of bilingual education as students will be able to gain subject specific language based competency and this may help learners to use subject-specific words in communication at global level hence increasing their social context of choice. General English words are translated as their primary language meaning is already known to the user.

6.2.2. Instructional design

Best-practices to teach computer programming give some good input to develop an appropriate prototype of intervention. Some major learnings from the literature review presented in Section 2.5.4 are listed here-

- Do not present a written source-code to the student, instead write the source-code at the time of teaching. This method is known as live-coding (Gaspar & Langevin, 2007) and helps students to gain confidence on overall process of writing code.

- Do not show the output directly but compile and execute the code at the time of writing (Rubin, 2013; Shannon & Summet, 2015). If some small error occurred at the compile or run time, explain the reason for error, this will improve their knowledge and understanding of source-code writing.

Literature review on cognitive load theory gives guidelines to visualize educational content types and multimedia principles to reduce cognitive load on students.

Literature review on use of visualization to teach various educational content type also gives some good input in creation of screencast to reduce cognitive load of the student. We first identified the content type (fact, process, concept, procedure and principle) then followed the guidelines given in Section 2.5.6 to develop educational content to provide cognitive scaffold to students.

Literature review on multimedia principles to reduce cognitive load (see. Section 2.5.6.2) gave some inputs to present the content in educational screencasts. We used attention-cueing, verbal redundancy, segmentation and split-attention technique to reduce cognitive load of student.

6.2.3. Third intervention prototype

Based on the findings from the literature review we developed a prototype for intervention to scaffold vernacular medium students. Details of the prototype of intervention for this research cycle RC3 is given in Table 6.2.

Table 6.2 Details of intervention prototype developed in RC3

Elements of intervention	**Details of third prototype**
Subject	Computer programming
Topic	Topics are chosen from ACM CS curricula 2013.
Instructional Content	• Five short length cognitively scaffolded screencasts. • Recorded for the purpose of screencast based learning with the learning material prepared in Hindi language.
Treatment	• One day workshop • Self-paced environment • Watch videos

Third intervention prototype: Use of primary language as MoI in a self-study mode where student will watch the small educational video with his/her pace.

We created five slides with instructions written in Hindi. We transliterated semi-specialized and specialized vocabulary terms in slides. We created five screencasts on introductory programming using the Hindi medium slides. We used live-coding (Gaspar & Langevin, 2007) method as suggested by the literature. Screencasts were developed by mapping the topics and learning objectives from ACM CS curricula 2013. Video title, sequence number and its running time is given in Table 6.3. Videos were given to the students in the ascending order of sequence number.

Table 6.3 Videos created for RC3

Seq. no.	Video title	Running time (MM:SS)
1	Introduction to C++	06:33
2	First C++ Program	07:50
3	C++ program details	08:46
4	Comments in C++	07:27
5	Return statement in C++	04:52

6.2.4. Scaffoldings used in third prototype

In this section we present the details of scaffoldings used in third prototype. These scaffoldings are categorized into language-based scaffold, cognitive scaffold and affective scaffold.

6.2.4.1. Language-based scaffold

We used only Hindi screencast in this research cycle to test the effectiveness of cognitive scaffolds. Language based scaffoldings used in screencasts are presented in Table 6.4.

Use Hindi MoI for on-screen text and verbal explanation (Table 6.4, point 1). We used this scaffold in RC1 and RC2 but did not see the impact because of the problems in other elements of intervention. Hence, we decided to use this scaffold for third prototype as well.

Use general Hindi words, used in normal spoken Hindi, in verbal explanation (see Table 6.4, point 2). We identified this scaffold in RC2 when students complained about few difficult Hindi words, used in screencasts in verbal explanation. Hence, we decided to use normal spoken Hindi as a scaffold for this research cycle.

Transliterate specialized and semi-specialized words in both on-screen text and verbal explanation (Table 6.4, point 3). This scaffold was identified in RC2 when instructor used translation on subject-specific words and students and teachers listed it as a shortcoming. Teachers claimed that translating specialized vocabulary will never lead to increased English competency. Based on these findings we decided to use transliteration of specialized vocabulary. For example, for the semi-specialized word "documentation", translation is "प्रलेखन" and transliteration is "डॉक्यूमेंटेशन".

Explain specialized and semi-specialized terms in detail on its first occurrence (Table 6.4, point 4). We identified the need of this scaffold in RC2 when students asked questions related to specialized words. When we analysed the transcript of the selected screencast (Table 5.14) we found that instructor used few specialized terms (execute, compile, parameter etc.) in screencast without explaining them and students were facing problems in comprehending the learning material. We used this scaffold in this prototype (RC3) to measure its effectiveness.

Code-switching (Table 6.4, point 5) has become the necessity for this prototype as we are using Hindi MoI and decided not to translate the specialized and semi-specialized words. Code-switching is a technique used by instructors to provide support to students. In this technique instructor switches his choice of MoI from primary to secondary and again switch it back to primary based on the requirement of the student. The literature review related to code-switching is presented in 2.5.2.2. Our purpose of using code-switching is to help learner to build specialized and semi-specialized vocabulary while using Hindi as MoI.

Table 6.4 language-based scaffoldings used in third prototype

No.	Detail of scaffolding in Hindi screencast	Where to use
1	Use Hindi MoI	On-screen test, Vocal explanation
2	Use general Hindi words if vocal explanation is Hindi.	Vocal explanation
3	Transliterate specialized and semi-specialized words.	On-screen text
4	Explain specialized and semi-specialized words on first occurrence	
5	Code-switching	Vocal explanation

6.2.4.2. Cognitive scaffolds

Cognitive scaffolds are used to reduce intrinsic cognitive load or extrinsic cognitive load of vernacular medium students. Vernacular medium students face high cognitive load when English MoI are used because he/she has to translate the presented material. The reason behind providing cognitive scaffold is to reduce the cognitive load on a student that a learner has to translate the presented material. We conducted literature review and found visualization guidelines (Section 2.5.6.1) and multimedia principles (Section 2.5.6.2) to reduce the cognitive load on students.

Segmentation, pre-training (Table 6.5 , point 1) and 'visualization guidelines to teach various educational content' (Table 6.4, point 2) were identified in literature review conducted to solve the problems of RC2. In RC2, students reported several problems in understanding the presented content. To identify the problems, we conducted literature review on teaching content in 'need analysis phase' of this research cycle. We found that segmentation, pre-training and "visualization guidelines to teach various educational content" not only help in developing the content but also in reducing the cognitive load of students. In this research cycle we design a prototype by following these principles and conduct a qualitative study to measure the effectiveness of these cognitive scaffolds.

Table 6.5 Cognitive scaffoldings used in third prototype

No.	Detail of cognitive scaffolding	Type of cognitive load it reduce.
1	Use of Segmentation and pre-training	Intrinsic
2	Use of visualization guidelines to teach various educational content	Intrinsic
3	Use of "multimedia principles to reduce cognitive load"	extrinsic

"Multimedia principles to reduce cognitive load" (Table 6.5, point 3) were identified in literature review conducted to solve the problems of RC2. In RC2, students reported several problems in the way content was presented in screencasts. To identify the problems, we conducted literature review on educational content presentation in 'need analysis phase' of this research cycle (RC3). We found multimedia principles not only helped in content presentation but also reduced the cognitive load. The multimedia principles that were selected and used in this thesis are: split-attention effect, redundancy effect, verbal redundancy, synchronization and attention-cueing (Table 6.6). We designed a prototype by following these principles and conducted a qualitative study to measure the actual effectiveness of these principles.

Table 6.6 Multimedia principles to reduce cognitive load

No.	Multimedia principles to reduce cognitive load	Type of cognitive load it reduce.
1	Split-attention effect	Extrinsic
2	Redundancy effect	Extrinsic
3	Verbal redundancy	Extrinsic
4	Synchronization	Extrinsic
5	Attention cueing	Extrinsic

6.2.4.3. Affective scaffolding

We provided affective scaffolding similar to RC2 as we were unable to see its effect because of content and presentation related problems.

Table 6.7 affective scaffolding used in third prototype

No.	Detail of affective scaffold
1	Screencast based self-paced learning environment

6.2.5. Design of learning material

Choice of programming language: In RC2 teachers reported "use of two programming language" as one of the shortcoming of screencasts. Hence, we decided to use only one programming language to teach programming construct. Syntax of input/output statement has less number of elements to remember, that may reduce the intrinsic cognitive load on the student. Hence we decided to use C++ over C for this prototype.

Choice of operating system: In RC2 teachers and students both reported problem of Linux environment for the beginners. Teaching programming is our main focus, not teaching the use of Linux. Hence, we decided to choose windows operating system as this is being used in the lab of the colleges and provide a GUI based environment. The use of GUI environment reduced the number of steps a student need to remember to perform a task, this may reduce the extrinsic cognitive load on the student.

Choice of development environment: In RC2 teachers and students both reported the shortcomings of the use of terminal and GEDIT to write and compile a program. Teachers suggested using an integrated development environment (IDE) for this purpose. We tried many IDE and selected code::blocks[4] IDE because 1) it uses GCC compiler to compile the program, 2) its interface is simple and has only few elements, and 3) it is not necessary to write *getch*() function at the end of the program just to stop the output window. Use of an IDE will reduce the number of steps required to edit, compile and run the program and this may reduce the extrinsic cognitive load on the learners.

We designed all content by following visualization guidelines and multimedia principles listed in Section 2.5.6.1 and Section 2.5.6.2 respectively. This section presents the sample of content developed in this phase of research cycle.

6.2.5.1. Split-attention effect

Literature review of split-attention effect is presented in section 2.5.6.2.1, its cause, effect and how to reduce this effect are mentioned there. Here we are presenting how we designed the learning material to reduce this effect. Figure 6.1 presents a screenshot from the learning material from previous RC and Figure 6.2 shows a screenshot from this RC during the presentation.

[4] http://codeblocks.org/

Figure 6.1 Screenshot of the screencast used in previous research cycle (RC2)

Figure 6.1 and Figure 6.2 show screenshots from a screencast used in RC2 and RC3 respectively. In both screencasts, instructor is explaining an error in the program. In Figure 6.1 the screen shows only error message. If user wants to see corresponding program, he/she has to jump backward in video timeline. At a time either program or its error can be seen but not both. In Figure 6.2 the screen shows errors and corresponding program on the same screen. This way learner does not need to mentally link two separate screens. This will reduce the split-attention effect and save learners time.

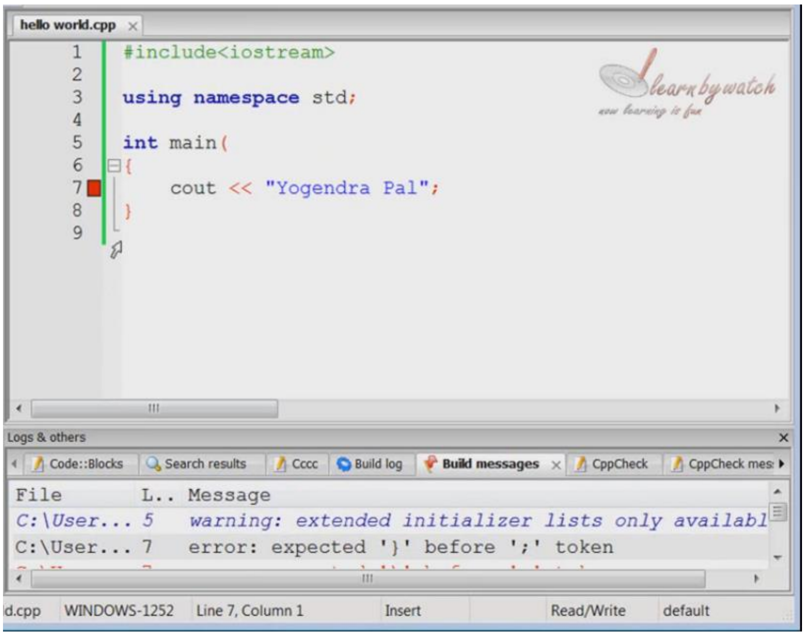


Figure 6.2 Screenshot of screencast used in this research cycle.

6.2.5.2. Segmentation

Computer programming is a complex subject. One program can have many elements. Teaching all elements in the same screencast. This may overload the working memory of learner and learner will not be able to understand the concept. Possible solution to this problem is segmentation as presented in section 2.5.6.2.2. We achieved segmentation by creating small chunks of videos. These segments and description of each segment are presented in Table 6.8. Each segment represents one screencast.

Table 6.8 Segmentation of screencasts and description of each segment

Segment no.	What is taught	Logic of segment
1	How to write the minimum skeleton of c++ program.	We used only those statements without which a program cannot be compiled.
2	How does minimum skeleton of C++ program work?	We explain the working of minimal skeleton of c++ program in this segment.
3	Comments in C++	In this segment we focused only on teaching the use of comments. Learner will focus only on learning comments, not the working of program as that is already covered in previous section.
4	Return statement in C++	In this segment, we introduce return statement, as user already knows the working of program and comments, he will focus only on return statement.

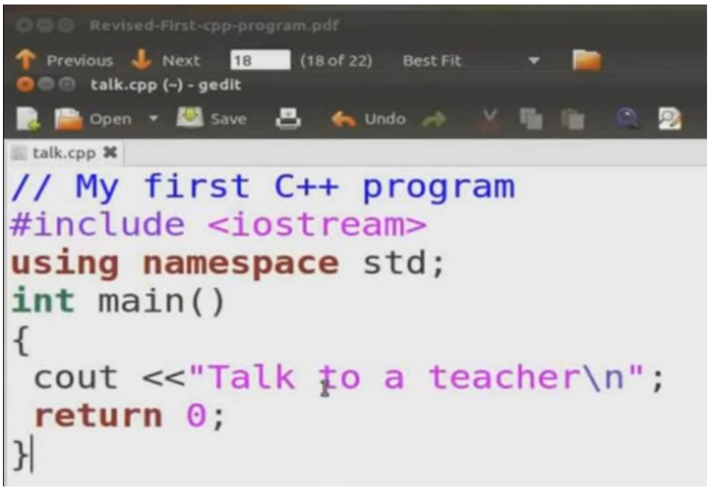


Figure 6.3 Screenshot from the screencast used in previous research cycle.

The screencast used in previous research cycle (RC2) did not follow the principle of segmentation. Figure 6.3 shows a screenshot of first tutorial of screencast used in RC2. The screenshot is taken at 00:06:35 second. Instructor has introduced the comments and return statement along with minimal skeleton of c++ together, within few minutes. This will overload the working memory of a student resulting in intrinsic cognitive overload and student will not be able to comprehend the learning material.

6.2.5.3. Redundancy effect and verbal redundancy

Redundant information overloads both the visual and auditory channels as same information is provided using two different medium simultaneously. To reduce redundancy effect, we used short on-screen text, read it and then explain it with narration.

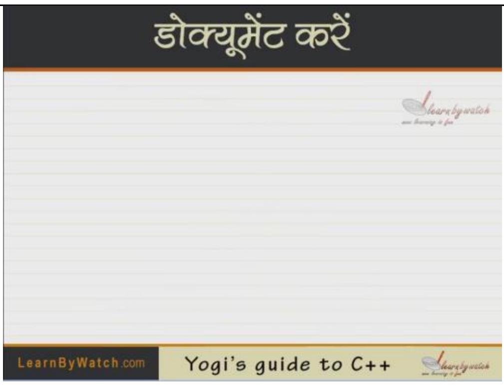
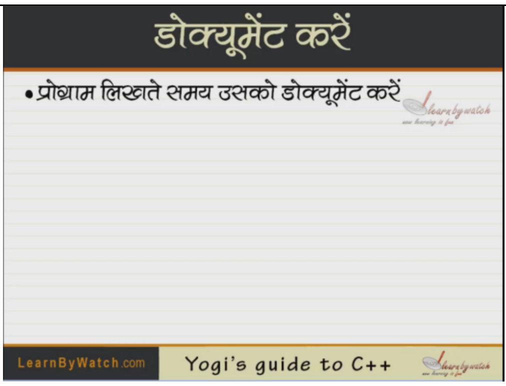
Use on-screen text with narration: We wrote short on-screen text, we read it first and then used audio to explain it. This way learners will not keep reading the on-screen text (as instructor has read it for them) when instructions are being presented in verbal form. Table 6.9 presents the slides with each line and how these lines are first read and then explained.

6.2.5.4. Attention cueing

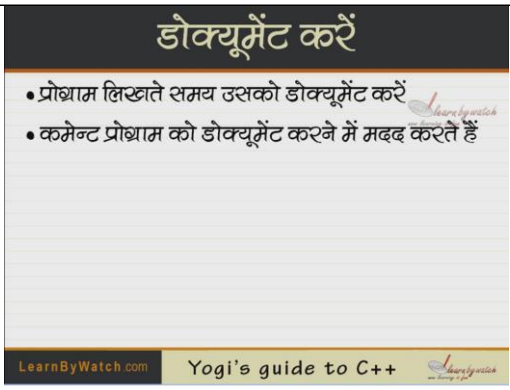
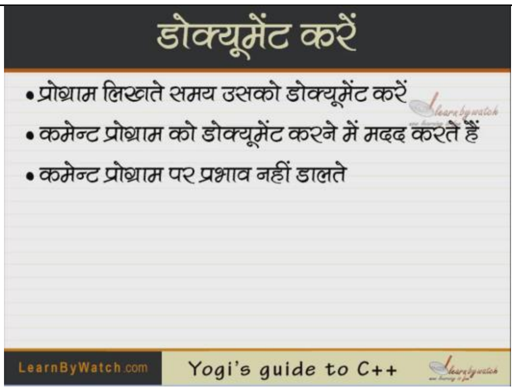
One line at a time: Presentation was created with one line at a time animation effect. Table 6.9 shows how slide changes with time during content presentation. This gives the opportunity to present one line at a time during content presentation. Students reported the use of line by line presentation useful (Apperson, Laws, & Scepansky, 2008). At a particular instance of presentation computer screen might be showing N number of lines but last appeared line is being explained vocally. Hence the student could predict which line is being explained and did not lose his focus in searching the information on slide.

Table 6.9 shows an example of a slide presentation during content presentation. This example shows the various instances of a slide and how they change with time and use of attention cues with the vocal explanation of the content.

Table 6.9 Example of a slide presentation in RC3

Time (m:s)	Screenshot of screencast	Explanation
0:16		A slide appears with title of the slide. Body of the slide is empty. ***Teacher***[5]***:*** Let us talk about why use comment in a C++ program.
0:22		(00:22) First line appears on the slide body. ***Teacher:*** (continue from previous) (Read the appeared line) ***Document the program while writing.*** (Explaining the on-screen text.) Documents make it easier to understand the program in future.

[5] Vocal explanations are translated in English in this thesis for better understanding, originally it was in Hindi.

<table>
<tr><td>0:52</td><td>
</td><td>(00:52) Second line appears on the slide.
Teacher: (read the line) comments help to document the program. (Explain the line) hence document the program with the help of comment.</td></tr>
<tr><td>0:58</td><td>
</td><td>(00:58) Third line appears on the slide.
Teacher: a good thing about comment is that (read the line) comments do not affect the program (verbal explanation) but we can see it. (more explanation provided)</td></tr>
</table>

Use of mouse cursor for attention cueing: Mouse cursor is also used to provide attention cue during explanation of IDE interface. As IDE interface has many elements i.e. menu, icons, tabs, sidebars, programming area, it is important to provide attention cue to the element being explained. As an example, during explanation of an error in a program instructor used mouse pointer as attention cue to indicate where error was being presented on computer screen. See Figure 6.4, notice the position of mouse pointer.

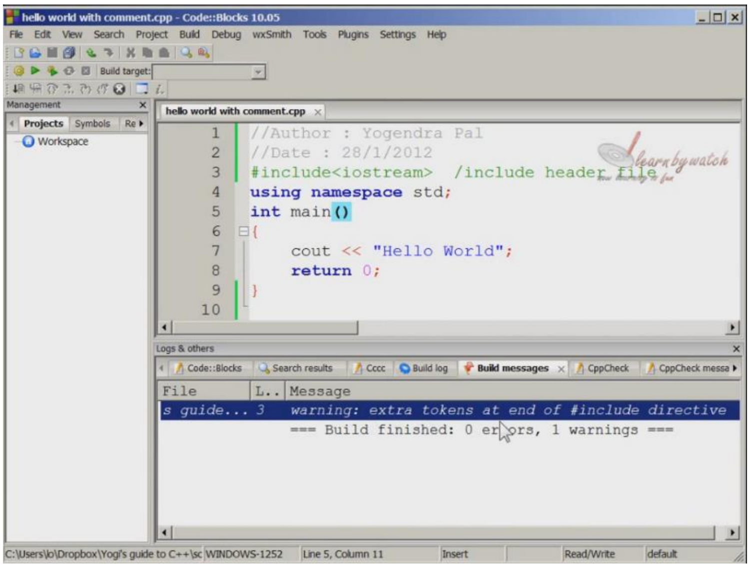


Figure 6.4 Attention cueing using mouse cursor to explain element

6.2.6. Research Design

We created learning material on introductory programming for screencast based self-paced learning environment. The screencasts selected for the study were in Hindi MoI. We chose five students, to do a micro-evaluation to test the actual effectiveness of the prototype. There were two goals to do a micro-evaluation, one, to confirm that cognitively scaffolded screencast is useful for vernacular medium students and second, to gain new insights on shortcomings and usefulness of the prototype.

6.2.6.1. Sample

The sample of micro-evaluation was five undergraduate vernacular medium students. We included only those learners who were 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.

6.2.6.2. Instruments and Data Collection

To measure actual effectiveness of the learning material, student's interview and questions about content were collected using micro-evaluation method. 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 a pre-test.

6.2.6.3. Procedure

Measuring Actual effectiveness:

Survey: We first conducted the survey and selected vernacular medium students based on the medium of their 12th Std. 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. Among all students we selected only five students for the study.

Arrangement: Every student was given a separate computer with the headphone. Students were allowed to watch the videos in the fixed sequence, decided by the researcher. Total length of five videos was 35 minutes 46 seconds. Each student was given a notebook with pen to make notes and write questions.

Treatment: Students were watching screencast at their own pace. Students were asked to write the questions on the notepad, if they had any and teacher will answer all the questions after they finished watching all the videos. There was no time limit, students were free to watch videos as long as they wanted. There were no additional tutorials or laboratory exercises. Each student was free to use video player controls according to his/her need.

6.3.Evaluation phase

To measure actual effectiveness, we transcribed and analysed student interviews and questions generated by them using content analysis (Krippendorff, 2012). Categories of the codes are 1) Effectiveness of Hindi MoI, 2) Effectiveness of transliteration, 3) Effectiveness of instructional design, 4) Effectiveness of choice of development environment/tool and 5) Effectiveness of presentation style. Within each category we initially coded student's description of the shortcoming and usefulness of the method used in the screencasts. The codes describing non-unique/overlapping behaviours were then merged. The final list of codes along with their category is given in Table 6.10 below.

Table 6.10 Category and codes of content analysis in RC3

Category	Code
Effectiveness of Hindi MoI	Effectiveness of use of on-screen text Effectiveness of use of vocal explanation.
Effectiveness of transliteration	Effectiveness of use of on-screen text. Effectiveness of use of vocal explanation.
Effectiveness of instructional design	Effectiveness of content sequencing. Effectiveness of content chunking. Effectiveness of instructional gap.
Effectiveness of choice of environment/tool	Effectiveness of use of windows OS. Effectiveness of use of IDE
Effectiveness of presentation style	Effectiveness of use of multimedia principles.

Effectiveness is measured by knowing shortcomings and usefulness in each code category. Vernacular medium students reported several shortcomings in receiving educational content in Hindi MoI and use of transliteration in screencasts during interview. Students questions did not indicate any shortcomings about content sequencing, chunking. One shortcoming in instructional gap was reported by students. Students did not ask questions related to use of operating system and IDE. This indicated that use of windows and code::blocks IDE was helpful to students. Few comments of students during the interview indicated the shortcomings of content presentation and need to improve it for next research cycle.

Vernacular medium students suggested the use of English MoI for on-screen text. They mainly gave three reasons behind this-

1. They have studied English in K-12 hence they can understand the on-screen text written in English if the amount of text is similar to the amount used in screencasts.

2. They face problems only when verbal explanation is provided in English MoI, so on-screen text should be in English, not in Hindi.

3. They will not gain English competency by using Hindi MoI in on-screen text and verbal explanation.

Vernacular medium students suggested using transliteration of specialized and semi-professional words only in verbal explanation not in on-screen text. They believed that this will help them in remembering the spellings of the words and they will gain confidence in using these terms in exams.

Few of the student's questions were related to code::blocks IDE. For example- "From where they can open it in their computer?", "How to install it?" etc. These questions indicated one instructional gap, i.e. screencast teaching the use of code::blocks IDE without teaching its installation. Students did not ask any questions related to the use of comments, return type and other programming construct.

On asking the question about the content presentations, students suggested using bright colours in presentation but also reported that the way content is presented did not create problem in comprehending the presented content.

Overall, students reported that the screencasts were useful to them to comprehend the learning material. Their high satisfaction was reflected from their demands of screencasts for more subjects like mechanics and electronics engineering with appropriate changes (as suggested by students) in MoI.

In this section we presented the actual effectiveness of the created screencasts. The actual effectiveness was measured by students using micro-evaluation and interview. Findings are presented in Table 6.11 that lists usefulness and shortcomings that confirms that intervention was useful for vernacular medium students.

Table 6.11 Actual effectiveness of screencast used in RC3

Reason of acceptance of the screencast
Pace of verbal explanation is appropriate.
Use of transliteration of subject-specific words in verbal explanation will improve English competency.
Feeling confident that whatever they were understanding is correct.
Reason of rejection of the screencasts
Use of transliteration of subject-specific terms in on-screen text decreasing their confidence of using these terms in exams.
Use of Hindi MoI in on-screen text is decreasing their confidence of using English in writing exams.
Instructional design problems
Questions were asked about installation of code::blocks IDE.
Presentation style
Presentation is simple but use of bright colors are suggested.

6.4.Problem resolution phase

In this research cycle we try to reduce the cognitive load on student by providing cognitively scaffolded screencasts to them. We found that students were able to comprehend the learning material and did not ask questions related to programming construct. Hence, we can say that systematic design of instructional material by following “instructional design principles” and “visualization guidelines to teach various educational content” help students to comprehend the material. Hence, we decided to keep using these principle for next research cycle.

Treatment: The treatment of this research cycle (RC3) and previous research cycle (RC2) was the same. Students were watching short screencast in self-paced mode. Students did not report any shortcoming in treatment in both research cycle. Hence, we decided to use it for further research cycles.

Use of MoI: Students of HH group complained about the Hindi on-screen text in screencasts. All students recommended using English MoI for on-screen text. A need to change the screencasts with on-screen English text was clear after this research cycle.

Instructional design: Topics were chosen based on the recommendation of ACM CS curricula 2013. Instructions were planned, developed and presented using instructional design principles, visualization guidelines to teach educational content and multimedia principles. Students did not report any problem in chunking, sequencing and instructional gap in the screencast. Since, we did not get any insight on shortcomings of educational content in the screencasts from the questions generated by users, more analysis was required to find the shortcomings and confirm the usefulness.

Presentation problem: Students did not complain about monotony for the screencasts but the suggestions we got was to use the colour in screencast.

6.4.1. Impact of scaffolding on learning

“Use Hindi for vocal explanation”, this scaffold has shown positive effect and found useful in the qualitative study conducted in this research cycle.

“Hindi MoI for on-screen text”, we assumed that vernacular medium students will find it helpful to use Hindi MoI for on-screen text. But, students reported its shortcomings and suggested to use English only instructions for on-screen text. We implement and test their suggestion in next research cycle (RC4).

“Explain specialized and semi-specialized words on first occurrence”, this scaffold is found useful for students. Students did not asked the meaning of any specialized or semi-specialized word.

“Transliterate specialized words for on-screen text”, shortcomings in this scaffold are reported by students. They claimed that they could read and comprehend short sentences from screencasts and use of English for on-screen text also helped them to develop English competency by improving their English vocabulary.

“Code-switching”, mix of Hindi and English MoI for vocal explanation is found useful in this research cycle. We used English MoI to pronounce specialized and semi-specialized words.

Segmentation, pre-training, ‘visualization guidelines to teach educational content’ and ‘multimedia principles’ are found useful to vernacular medium students as students didn’t reported any shortcomings for these cognitive scaffold.

Screencast based self-paced environment was similar to previous research cycle but this time with the help of other scaffold used in this research cycle, students reported that they feel confident that they have understand the content correctly. The effect due to self-paced environment is visible in this research cycle. So, we decided to use it for further research cycles.

6.5. Summary

In this research cycle we measured the actual effectiveness of the cognitively scaffolded screencast to teach programming. We want to validate the findings of literature review about reducing cognitive load using multimedia principles and visualization guidelines to teach educational content. We found that screencasts recorded by following visualization guidelines to teach various educational content and multimedia principles helped students to comprehend the material. Students reported of using English on-screen text in screencasts. This removes the need to transliterate subject specific words in educational text. Students believed that the use of Hindi MoI in verbal explanations of English educational text helped in understanding the content and improving their English competency.

The summary of this research cycle is presented in Table 6.12 that shows the assumptions, actions and findings of this research cycle, actions for next research cycle, and guidelines for further research cycles. The problem of this RC is addressed in next research cycle (RC4) that is described in chapter 7.

Table 6.12 Summary of third research cycle

Assumptions	**Actions**	**Findings**	**Actions for next RC**	**Recommendation for guidelines**
Students will report the usefulness of transliteration of subject specific-terms in Hindi MoI screencasts.	Transliteration of subject-specific terms are used in written form of educational content.	Students find transliterations of subject-specific terms in written educational content as not required.	Do not transliterate subject specific terms in educational text.	Do not transliterate subject specific terms in educational text.
Use of general Hindi terms used in normal conversation to deliver the educational content in Hindi MoI will make it easy for vernacular medium students to comprehend it.	Vocabulary of general spoken Hindi is used in creation of educational content.	Students reported it unnecessary to use Hindi text in written educational content as they can read the content written in simple English.		
		Use of Hindi written text in educational content is criticized by students.	Do not use Hindi text in written educational content.	Do not use Hindi text in written educational content.
Verbal explanations of educational content in Hindi MoI will help in comprehension of educational content.		Verbal explanations in Hindi MoI were appreciated by students.		Verbal explanations of English educational text help students in understanding the content and improve their English competency.
		Students suggested that use of English for educational text in slides and verbal explanation in Hindi MoI would help them in understanding the content and increase their English proficiency.	Use English in written educational content along with verbal explanation in Hindi MoI.	

			Conduct literature review on using two languages for vernacular medium students.	
Educational content created by following instructional design principles will have no instructional gap and sequencing and chunking will be appropriate.	Content is planned using instructional design principles.			
Students will not report shortcomings indicating instructional gap and content sequencing in educational content if it is created by following instructional design principles.		Students reported usefulness of the educational content created using instructional design principles.		Plan instructions using instructional design principles.
Educational content created by following "visualization guidelines to teach educational content" will help in selection and creation of appropriate examples, analogies and learning material.	Content was designed by following the "visualization guidelines to teach educational content".			
Students were not reporting shortcoming is selection of examples, analogies and learning material.		Students did not report any shortcomings in the educational content designed by following "visualization		Use of visualization guidelines (Section 2.5.6.1) is helpful to vernacular medium students.

		guidelines to teach educational content".		
Educational content presented by following multimedia principles will not be monotonous for the students.	Educational content was presented using multimedia principles.			
Students will not report any shortcomings in content presentation if multimedia principles are followed.		Students did not report any shortcomings in the presentation when multimedia principles were followed.		Use of multimedia principles helps vernacular medium students.

Chapter 7

Research Cycle 4: Using two languages in classroom

Details of third research cycle (RC3) are presented in Chapter 6 in which we try to find out the problems of vernacular medium students when they learn programming from cognitively scaffolded screencasts in Hindi MoI. Students found the intervention of RC3 useful. We are able to design a partly-detailed prototype to teach programming to vernacular medium students based on the findings of RC2 and RC3. But, we did not get insights about shortcomings of intervention in RC3 hence, we decided to implement the findings of RC2 and RC3 in a classroom environment to collect more details about intervention. This chapter presents the details of fourth research cycle (RC4) which was carried out after resolving the problem of RC3 to test our semi-developed intervention in a classroom environment.

We are answering these major questions: The first major question is RQ4: What is the impact of the MoI on the programming abilities of primary language learners in the classroom? This is operationalized into the following specific questions:

RQ4.1: Do undergraduate Hindi medium students learning introductory programming in classroom in Hindi perform better than similar students who learn programming in Classroom in English?

In order to determine which content types (fact, process, concept, procedure and principle) should be taught in Hindi and which content types could be taught in English, we had the additional question:

RQ4.2: What is the effect of MoI for varying content types in programming instruction provided in general classroom setting?

In section 7.1 we describe the need analysis phase where we try to resolve the problems of research cycle 3 (RC3) presented in Section 6.4. Design and develop prototype phase is presented in Section 7.2, in which we choose a research design to answer the RQ4.1 and RQ4.2 and details of intervention provided to students. Section 7.3 of this chapter describes the evaluation methods used to measure the effectiveness of intervention. Section 7.4 of this chapter presents the problem resolution phase where we discuss the learnings and findings of this research cycle (RC4).

7.1.Need analysis phase

In this phase of this research cycle we try to resolve the problems of previous research cycle (Chapter 6) by literature review. In previous research cycle, Hindi medium students reported that Hindi text in slides was not required as they can understand the short English sentences and using English sentences on-screen text will help them to write in the exam. Hence, we decided to use English on-screen text for next intervention. Student's demand created a need for using two language instructions, thus we conducted literature review on bilingual education that is presented in detail in Section 2.5.5.

We conducted literature review to answer two questions: 1) How to create bilingual learning material for vernacular medium students? and 2) How do teachers teach vernacular medium students in two languages? Details of literature review for this section is presented in Section 2.3.2 and Section 2.5.5. The findings from previous research cycles and literature review are categorized into three categories: 1) language based, 2) educational content development, 3) educational content presentation and 4) choice of educational environment. Based on the learning from the literature review and findings from RC1 to RC3 (see Table 7.1), we made some assumptions about next intervention. The assumptions of this research cycle and corresponding action are presented in Table 7.2. The prototype for this research cycle is designed in "design and develop prototype" phase presented in Section 7.2.

Table 7.1 Findings of RC1 to RC3 that leads to intervention design in RC4

	RC1	RC2	RC3
Language based finding		1. Do not translate subject-specific terms. 2. Use general Hindi words while using Hindi MoI in teaching educational content.	1. Do not transliterate subject specific terms in educational text. 2. Do not use Hindi text in written educational content. 3. Verbal explanations of English educational text helps students in understanding the content and improves their English competency.
Findings related to educational content development.		1. Poorly designed Instructions create problem in learning.	1. Plan instructions using instructional design principles. 2. Create content using visualization guidelines to teach educational content.
Findings related to content presentation.		1. Monotonous content presentation is a barrier in learning.	1. Present content using multimedia principles.
Findings related to use of environment.	1. Do not use classroom recorded videos. 2. Videos should be used only in 1:1 self-paced environments.	1. Use self-paced study environment for vernacular medium students as it supports learning. 2. Use self-paced study environment to reduce affective problems of vernacular medium students.	

Table 7.2 Assumptions and actions for RC4

Assumptions	Actions
Vernacular medium students will face no difficulty in understanding written learning material in English if oral explanation is provided in Hindi in a classroom environment.	All written learning material were presented in English along with the Hindi explanation for one group (HHc) in classroom environment.
Vernacular medium students will face difficulty in comprehending the learning content, if written text and oral explanation both are in English MoI in a classroom environment.	All written learning material were presented in English along with the English explanation for another group (HEc) in classroom.
Use of simple general English words will help in understanding educational content presented in English MoI in classroom environment.	Use simpler English words rather than complex.
Explaining subject-specific and semi-specialized words on first occurrence will help them to comprehend the learning material presented in English MoI.	All subject-specific and semi-specialized words were explained in detail on first occurrence.
Use of slow pace for vocal explanation in English MoI will help vernacular medium students to comprehend learning material in classroom environment.	Slow pace is used to present content in English.
Instructions created by following visualization guidelines and multimedia principles to develop and present content will help in learning in classroom environment.	Create instructions by following visualization guidelines and multimedia principles to teach vernacular medium student in classroom environment.

7.2. Design and develop prototype phase

Based on the findings from previous research cycles and literature review we made some assumptions and based on these assumptions we take some actions to design the prototype for this research cycle. The findings and assumptions are given in Table 7.1 and Table 7.2 respectively. We could have used screencast to implement the findings but we want to get more insights on the problems of vernacular medium students. A classroom environment is where teacher can look at the students' understanding of the problems with the content and change instruction strategy accordingly. Hence, we decided to use classroom environment for this intervention.

7.2.1. Fourth prototype: two languages in classroom

Research cycles RC2 and RC3 gave input to design screencast for vernacular medium students. But, we wanted to get some insights directly from the students to reach to the final prototype. Hence we decided to conduct the experiment in general classroom setting as this gives the opportunity to interact with students and identify if they are facing any problems.

For this intervention, we decided to create multiple day training program. There are three reasons to use a multiple day training program. They are: 1) Students lose the concentration after few minutes in classroom environment. This problem was reported in literature review conducted to identify the problems of classroom environment (see Section 2.4). 2) In RC1 (see Chapter 4), we used classroom recorded videos in classroom environment for 3-hours and found that students did not perform well in post-tests. 3) Normal class time in an undergraduate course is 60 minutes to 90 minutes long, which was not sufficient to teach and test all the topics given in Table 7.8. Hence, we planned to teach few topics and conduct the post-test every day within the time limit.

Fourth prototype: This is use of primary language as medium of instruction in classroom environment where students receive instructions from teacher in face-to-face setting. Educational contents are created by following the 'visualization guidelines to teach educational content types' and teacher will present the material by following the multimedia principles and best-practices of computer science teaching. Text and source code is written in English on slides and recorded as on-screen text in screencast.

Table 7.3 Details of fourth intervention

Elements of intervention	**Details of fourth prototype**
Subject	Computer programming
Topic	• Topics from ACS CS curricula 2013: one knowledge unit. • Contains a mix of programming concepts, facts, processes, procedures and principles.
Instructional Content	Classroom teaching with learning material prepared using best practices of computer science teaching and following multimedia principles.
Treatment	6-day workshop Classroom environment Face to Face

7.2.2. Scaffoldings used in fourth prototype

In this section we present the details of scaffoldings used in this research cycle (RC4). These scaffoldings are categorized into language-based scaffold, cognitive scaffold and affective scaffold.

7.2.2.1. Language-based scaffold

In the previous research cycle we measured actual effectiveness of Hindi screencast using language-based, cognitive and affective scaffolding. Content analysis of student's interviews and questions generated by them reported shortcomings in use of "Hindi MoI for on-screen text" and "Transliterate specialized words for on-screen text". We removed these two scaffolds and redesigned the learning material (Section 7.2.3). We presented this learning material in a face to face classroom environment to get more insights on student's problems in receiving instructions from English MoI. We used Hindi MoI for HHc group and English MoI for HEc and EEc groups. The language based scaffoldings used in Hindi MoI classroom are given in Table 7.4.

Table 7.4 Language based scaffoldings for Hindi classroom in fourth prototype

No.	Detail of scaffolding in Hindi classroom	Where to use
1	Use Hindi MoI	Vocal explanation
2	Use general Hindi words in vocal explanation	Vocal explanation
3	Simple English for vocal explanation	
4	Write specialized and semi-specialized words in English	On-screen text
5	Code-switching	Vocal explanation
6	Explain specialized and semi-specialized words on first occurrence	

The language-based scaffolding for English MoI classroom is given in Table 7.5.

Table 7.5 Language-based scaffoldings for English classroom in fourth prototype

No.	Detail of scaffolding in English classroom	Where to use
1	Use simple general English words while using English MoI.	Vocal explanation, On-screen text
2	Explain specialized and semi-specialized words in detail on its first occurrence.	
3	Specialized words in English for on-screen text	On-screen text
4	Use slow pace for verbal explanation	Vocal explanation

7.2.2.2. Cognitive scaffold

The scaffold because of "segmentation" seems useful in previous research cycle but segmentation can be provided in a student-controlled environment. Hence, this scaffold is not available in this research cycle. The details of cognitive scaffoldings used in this prototype are listed in Table 7.6.

Table 7.6 Cognitive scaffoldings used in fourth prototype

No.	Detail of scaffolding to reduce cognitive load	Type of cognitive load it reduce.
1	Pre-training	Intrinsic
2	Create content using "visualization guidelines to teach educational content".	Intrinsic
3	Present content using "multimedia principles".	extrinsic

"Multimedia principles" (Table 7.6, point 3) were identified in literature review conducted to solve the problems of RC2. In RC2, students reported several problems in the way content was presented in screencasts. To identify the problems, we conducted literature review on educational content presentation in 'need analysis phase' of RC3. We found multimedia principles not only helped in content presentation but also reduced the cognitive load. The multimedia principles that were selected and used in this research cycle are: split-attention effect, redundancy effect, verbal redundancy, synchronization and attention-cueing Table 7.7. In RC3 we design a prototype by following these principles and conducted a qualitative study. Content analysis of student's interview did not report any major shortcoming in the content presentation in RC3. In this research cycle we conducted a quantitative study on 105 students in classroom environment with the content designed by following these principles to measure actual effectiveness of the prototype.

Table 7.7 Multimedia principles to reduce cognitive load

No.	Multimedia principles to reduce cognitive load	Type of cognitive load it reduce.
1	Split-attention effect	Extrinsic
2	Redundancy effect	Extrinsic
3	Verbal redundancy	Extrinsic
4	Synchronization	Extrinsic
5	Attention cueing	Extrinsic

7.2.2.3. Affective scaffold

In RC2 and RC3 affective scaffolding was provided with the help of self-study environment. In a face to face classroom students cannot match the pace of all students. Hence, there is no affective scaffold in this research cycle.

7.2.3. Design of learning material

We designed all content by following "visualization guidelines to teach educational content" listed in Section 2.5.6.1 and "multimedia principles" listed in section 2.5.6.2. This section presents the sample of content developed in this phase of research cycle.

7.2.3.1. Multimedia principles to develop educational content

The topics and their learning objectives are presented in Table 2.5 and Table 2.6 respectively. We planned content using instructional design principles and visualization guidelines of teaching various educational content types. Writing learning objectives was the first requirement to plan content. Table 2.6 gives the learning objectives to teach the topics listed in Table 2.5. Then we decided the pre-requisites for each topic to remove any instructional gap. We used segmentation and pre-training method to arrange the topics to reduce the cognitive load on students.

7.2.3.1.1. Segmentation and pre-training

Computer programming is a complex subject. There are many construct and understanding. One construct may need the knowledge of various other constructs. Off-loading technique suggests to using both visual and auditory channels to reduce extraneous cognitive load. Presenting a complex topic with off-load technique will easily overload both the channels and result in high intrinsic cognitive load. Using off-loading to teach complex constructs of programming will overload both the visual and auditory channels and learner will not be able to understand the concept. Possible solutions to this problem are segmentation and pre-training as presented in section 2.5.6.2.2.

Segmentation technique suggests to use learner-controlled segments by segmenting complete information into multiple segments and allowing students to navigate through them. Learner-controlled environment cannot be created in classroom hence segmentation is not possible in classroom environment. We can provide segmentation only for video based training, Table 6.8 presents the segmentations of screencasts in previous research cycle RC3. In classroom environment, these segments are presented sequentially by the instructor and learners have no control over them.

Pre-training can be provided in both classroom based and video based environments. An example of how we provide pre-training in our treatment is shown here. *If* statement in computer programming consists of 1) statements, 2) condition and 3) *if keyword* itself. Hence, we divided our training program in a way where we teach simple statements in one lesson and condition in a separate lesson. When we are teaching *if* statement, students shall be already familiar with some simple statements and condition. Similarly before teaching recursion, we provide pre-training in function, function calls, functions with parameter, and conditional statements. This will help in reducing intrinsic cognitive load as component model of statements and condition already exists and students will now focus only on developing causal model.

7.2.3.1.2. Identify the content type of each topic

We identified the content types of the topics to follow the appropriate visualization strategy to teach them. A detailed list of topics and its content types is given in the Table 7.8 according to the day of teaching. Literature review on visualization guidelines to teach educational content is given in Section 2.5.6.1.

Table 7.8 Topics and corresponding educational content type

Content Type	Topics to teach
	Day 1
Concept	Computer
Concept	Computer Program
Procedure	How to write a computer program
Procedure	Interface of code::blocks compiler
Procedure	How to write and compile a program in code::blocks
Process	How does a program compile
Fact	C character set
Concept	Escape sequence
Procedure	How to use /n /t in computer program
	Day 2
Concept	What is an identifier?
Fact	What are the rules to create identifier?
Procedure	Use code::blocks IDE
Concept	What are keywords?
Concept	What is data and why various data types are required.
Fact	What is char data type?
Fact	What is integer data type?
Fact	What is floating point number?

Fact	What is void data type?
Fact	What are the range of integer variable for 16 bit and 32 bit?
Procedure	How to create & access an integer type data in c program?
Concept	What is garbage value?
Fact	Facts one should know before using integer constant
Day 3	
Fact	What does *scanf*( ) do?
Procedure	How to use *scanf*( )?
Process	How does *scanf*( ) works?
Fact	What arithmetic operators can be used in c program?
Procedure	How to make arithmetic equation in a c program?
Process	How does a modulus operator work?
Process	How does compiler solve arithmetic equations?
Fact	What is assignment operator?
Process	How does multiple assignment execute?
Concept	What is compound assignment operator?
Procedure	How to use compound assignment operators?
Concept	Unary operator
Fact	Decrement and increment operator
Procedure	How to use increment and decrement operator in c program.
Process	How does pre and post decrement / increment operator works?
Fact	Operator precedence
Day 4	
Concept	Branching Statement
Fact	Facts about branching statement
Process	How does a if statement works?
Procedure	How to write if statement?
Fact	"==" relational operator
Fact	Work of various relational operators
Process	How does == work?
Process	How does != work?
Process	How does > work?
Process	How does >= operator work?
Process	How does < operator work

Process	How des <= operator work
Fact	Operator precedence
Procedure	How to write multiple statements in if statement?
Process	How does if statement with multiple line work?
Principle	Solving a programming problem that has conditions
Fact	Else statement
Procedure	How to write if-else statement?
Process	How does if-else statement work
Procedure	How to write if-else statement with multiple statements
Process	How does if-else statement with multiple line work?
Principle	Using if-else statements for programming problems.
Process	How does compiler execute if-else statement?
Process	How does compiler execute if statement with assignment and equal-to operator
Day 5	
Concept	Function
Procedure	How to create and use a function in c?
Process	How does a c program with functions execute in c?
Fact	Some facts about function call
Process	How does a c program with function works when it's returing nothing
Concept	Scope of variable
Principle	Building c programs with functions.
Concept	Call by value
Day 6	
Concept	Recursion
Procedure	How to solve a mathematical recursive function
Procedure	Convert a mathematical recursive function into a recursive function in c
Procedure	How to hand execute a recursive function
Principle	How to solve programming problems using recursive function

7.2.3.2. Multimedia principles to reduce cognitive load

7.2.3.2.1. Split-attention effect

Literature review of this effect is presented in section 2.5.6.2.1, its cause, effect and how to reduce this effect are mentioned there. We are presenting here how we designed the learning material to reduce this effect. Figure 7.1 and Figure 7.2 presents two screenshots from the learning material during the presentation.

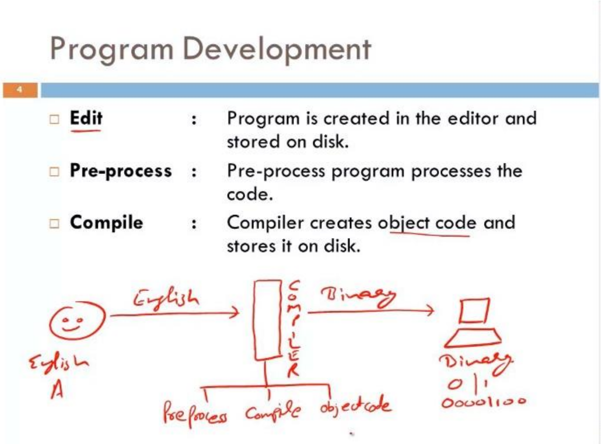


Figure 7.1 Reduce split-attention effect during slide presentation

Figure 7.1 presents a screenshot from screencast when program development process was being explained with the written text on slides, at the same time when need and work of compiler is explained. This way learner does not need to split attention between two screens, otherwise it will be explained in two screens and user needs to go back and forth to make sense of the content.

Similarly in Figure 7.2, the program and its corresponding output is shown on the same screen near each other. If program and its output will be presented in different frames in a video a student will be able to see either program or output at a time, so he/she needs to go back and forth to understand it. Presenting both, program and its output on same screen will reduce the problem of students arising due to split-attention effect of student.

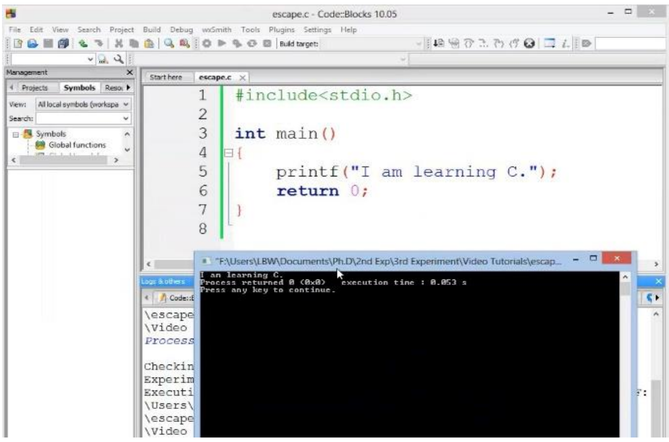
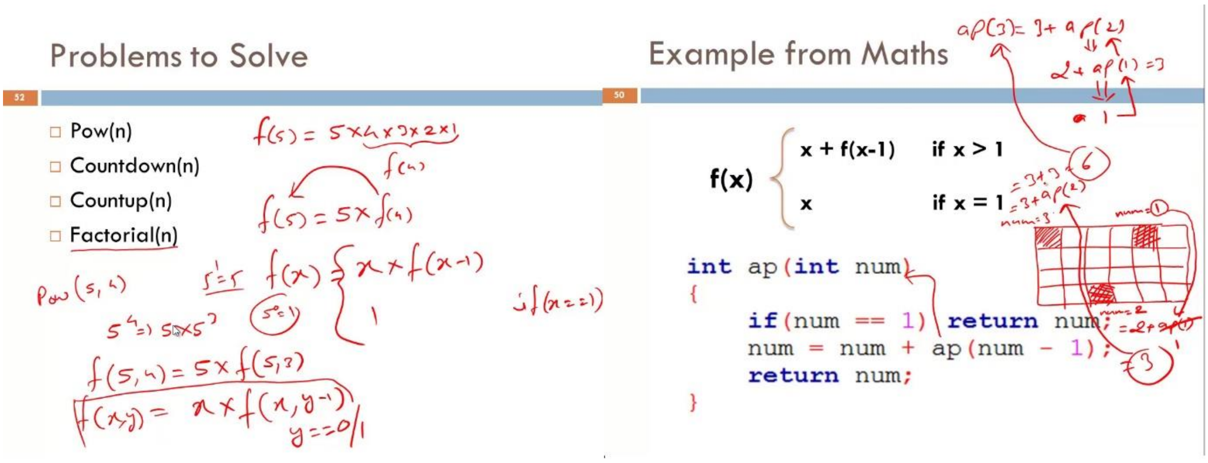


Figure 7.2 Reduce split-attention effect during live-coding

7.2.3.2.2. Redundancy effect and verbal redundancy

Use animation with narration: We are considering drawing on computer screen as animation, as its state is changing with the time. According to the redundancy effect when presenting animation, it is desirable to present the words in narration, not with onscreen text (Moreno & Mayer, 2002). Figure 7.3 shows two examples of using animation with narration, a) shows the screenshot, taken in classroom, where teacher is showing a recursive function in mathematics using on-screen drawing using digital pen with the narration, b) shows the screenshot, taken in classroom, where instructor is showing a recursive function in context of programming and how variables store in computer memory using on-screen drawing and voice narration. Live coding and hand execution of both the mechanisms follow same principle and hence reported effective in teaching programming. Hence, we see that best-practices, being followed by many teachers and proven to be effective because best-practices follow some principles from cognitive-load theory.



a b

Figure 7.3 On-screen animation with narration

Use on-screen text with narration: presenting on-screen text with narration without using other visual is known as verbal redundancy as the written text is being presented using verbal and auditory channel. Mayer found this effective as there is no animation or complex visual that will overload the visual channel. Hence, we decided to use on-screen text with narration. We used a short on-screen text and when it appeared on screen, we read it and then explained it with verbal explanation.

7.2.3.2.3. Synchronization

Draw and explain simultaneously: Mayer suggested using synchronization to reduce the cognitive overload that occurs when learner tries to select, organize and integrate material that explains how system works. We used synchronization at the time of explaining how a programming construct or how a program works. Because understanding the working of a program required selecting, organizing and integrating several pieces of information together. Figure 7.4 shows an example of synchronization where we use verbal explanation in synchronization with on-screen drawing. In this example, instructor explains how a recursive function works. Three ovals on the screen show three different piece of information used to explain the working of recursive function. These ovals are not part of tutorial. These three types of information are recursive function, memory representation of the function and steps of each recursion. On-screen drawing helps in selecting the components, organizing them one-by-one and integrating them to explain the working of a programming construct. If this information was presented without screen-drawing or any kind of visualization, students would keep looking for the component that is being explained (select), order of component (organize) and would be unable to make relation between three types of presentations. Synchronization will help students to reduce intrinsic cognitive load.

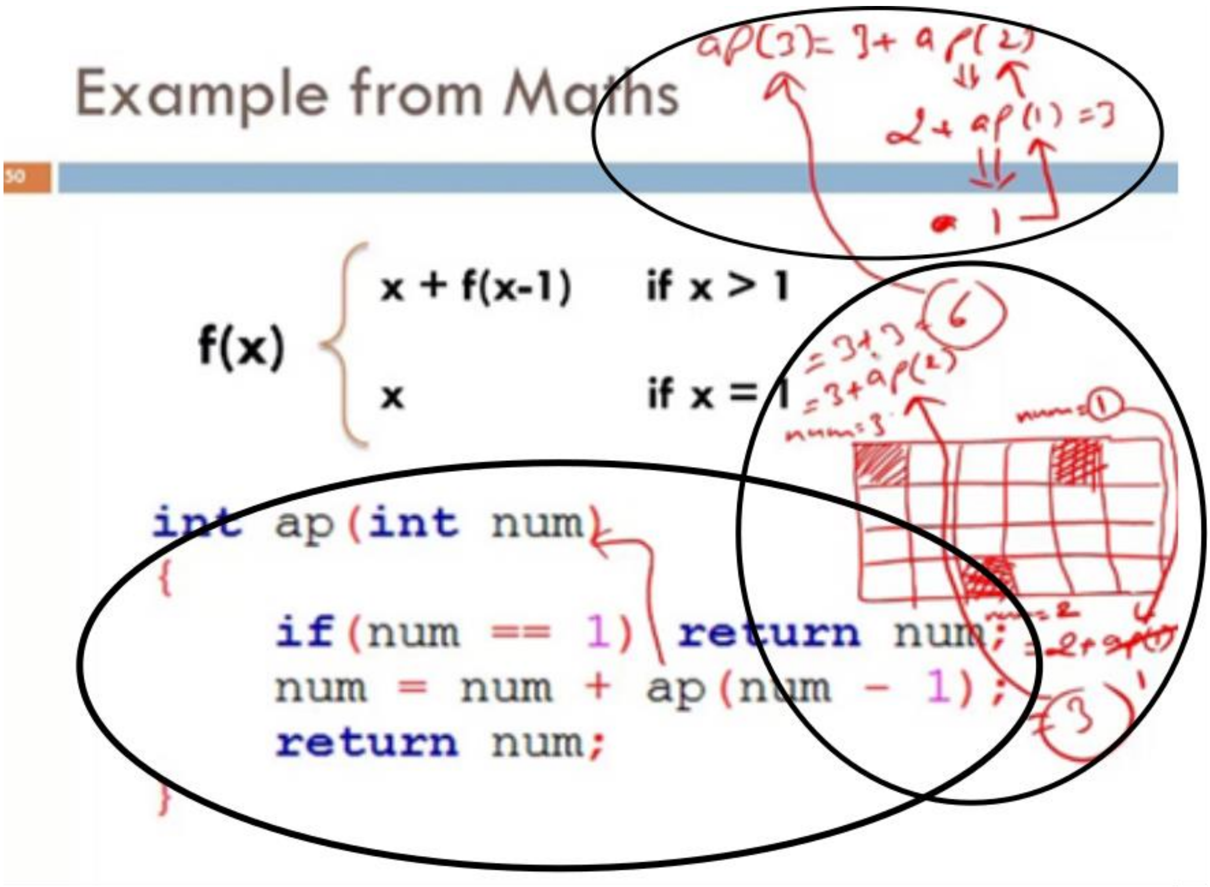


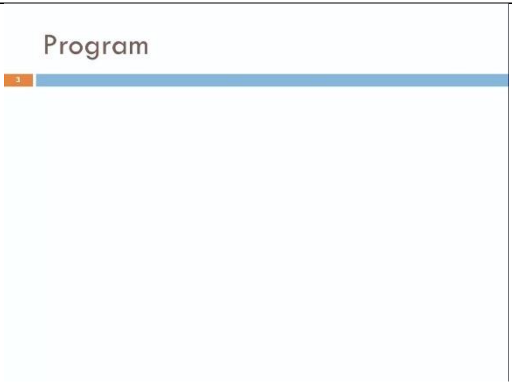
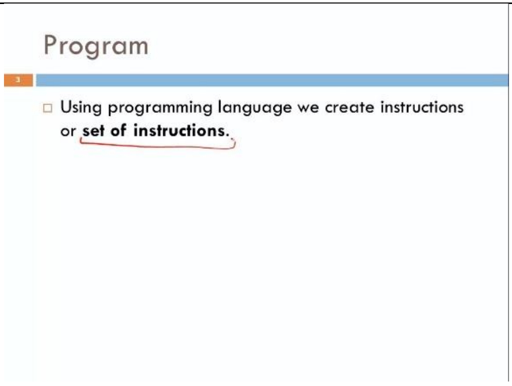
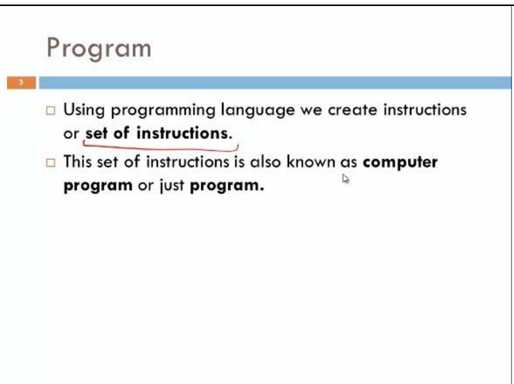
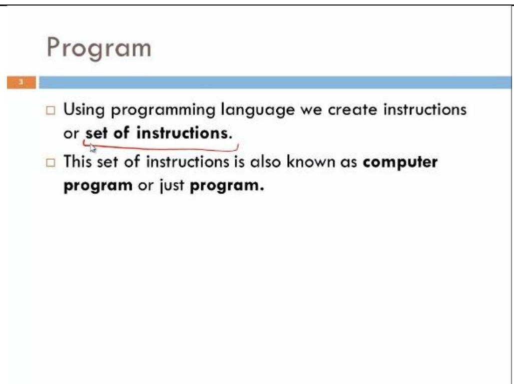
Figure 7.4 Synchronization of visual and auditory information

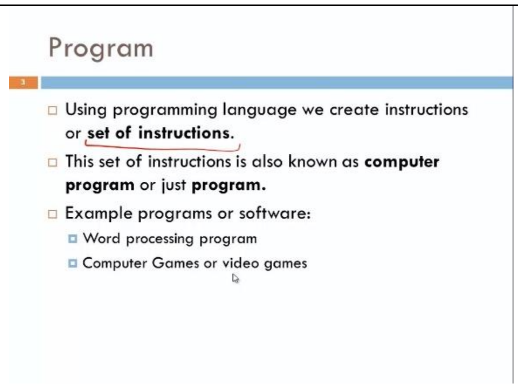
7.2.3.2.4. Attention cueing

One line at a time: Presentation was created with one line at a time animation effect. Table 7.9 shows how slide changes with time during content presentation. This gives the opportunity to present one line at a time during content presentation. Students reported the use of line by line presentation useful (Apperson et al., 2008). At a particular instance of presentation computer screen might be showing N numbers of lines but last appeared line is being explained vocally. Hence, student could predict which line is being explained and would not lose his focus in searching the information on slide.

Table 7.9 shows an example of a slide presentation during content presentation. This example shows the various instances of a slide and how they change with time. I shows the use of attention-cues, line by line explanation and with the vocal explanation of the content.

Table 7.9 Example of a slide presentation

Time (m:s)	Screenshot of screencast	Explanation
2.56		A slide appears with title of the slide. Body of the slide is empty. ***Teacher:*** So, we should know about the program. What is a program? A program is nothing
3:13		(3:01) First line in the body appears on the slide. ***Teacher:*** (continue from previous) but a set of instructions. (Read the appeared line with attention cue using mouse pointer) Using programming language we create instructions or set of instructions. ***Teacher:*** (Attention cueing to the important words.) This set of instructions is called program.
3:18		(3:15) Second line appears on the slide. ***Teacher:*** (read the line with attention cue using mouse pointer) This set of instructions is also known as computer program or just program.
3:26		***Teacher:*** (explaining this line) So if you want to give instructions to your computer you need to write a program or (attention cueing to make relation with previous line) set of instructions. {see mouse pointer on previous line}

3:50		***Teacher:*** Let us see some examples of programs or software. You know word processing program, Microsoft word or if you have used open office also. These programs WordPad or notepad are also word processing programs. The same way, if you have played any game, any computer games, these are also examples of programs.

Use of mouse cursor for cueing: Instructor used mouse cursor to seek attention of learner while a line is being explained during content presentation. At a particular instance a computer screen may contain many sentences and each line contains many words.

As Hindi medium student is not proficient in receiving English medium instruction, it is necessary to seek his attention to the sentence or word that is being explained. See Table 7.9 to know how position of mouse cursor changes with the time. Notice cursor position at 3:18 and 3:50, mouse cursor is below the word of last line that is being explained at that time.

Sometimes current sentence has some relation with the previous sentence. In that case current sentence will be explained by referring to the previous sentence. Notice cursor position at 3:26 where last line is being explained but cursor is at previous line. Attention cueing at this complicated situation helps learner to focus only on content (not on searching what is being explained) by saving his/her time in searching the information.

Mouse cursor is also used to provide attention cue during explanation of code::blocks IDE interface. As code::blocks IDE interface has many elements i.e. menu, icons, tabs, sidebars, programming area, it is important to provide cue of the element we are talking about. As an example, during content presentation, author created a new file and the name of this file is automatically decided by the IDE. This name is displayed in the tab and title bar of the IDE. Author said while providing cues with mouse pointer – “The name of this file is untitled 2”. Figure 7.5 shows the screenshot of that time. There are more than 75 elements on the screen. Without the cue learners will not be able to identify the element instructor is talking about.

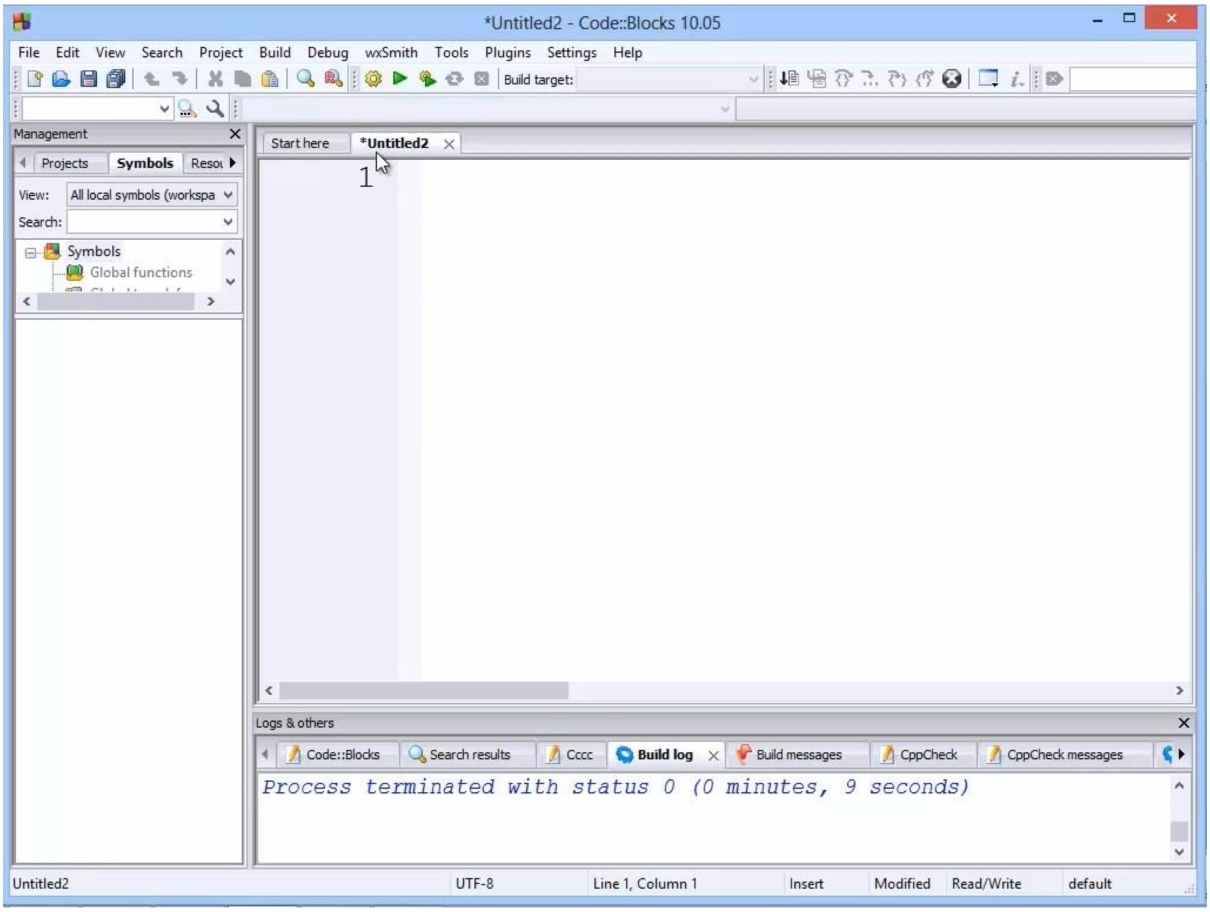


Figure 7.5 Attention cueing using mouse cursor to explain element

Colour coding: Colour coding is used to highlight words phrases and elements of source-code in the lines. Colours gains the learners attention towards important points. A source-code presented with colour helps learners to identify keywords, functions, variables and other elements separately and make source code more readable. In our case, we used colours to highlight text in slides, source code and on-screen drawing. We used an IDE that highlighted the source-code automatically. The screenshots taken after writing program in IDE are embedded in our slides. This avoids the chances of using different colour-coding in slides and IDE.

```
#include<iostream>
using namespace std;
int main()
{
  Cout<<"Hello World";
}
```

Figure 7.7 Example of use of source-code in slide in RC3

Figure 7.7 shows an example of source-code used in slide in previous research cycle (RC3). In RC3, students suggested using bright colors to make the presentation more attractive. During literature review we found that use of colour can also lead to better learning because it acts as attention-cue and helps in reducing cognitive load.

```
#include<stdio.h>

int main()
{
    printf("I am learning C");
    return 0;
}

```

Figure 7.6 Example of use of source-code in slide in RC4

Figure 21 shows an example of source-code used in slides. This looks better than the previous one and helps students to guide attention to the coloured elements. During the presentation we told that bold blue colour is being used to represent the keywords. It might be possible that when instructor say look at the keyword in this program (without use of any other attention-cue) students will neglect other elements and start focusing only on *int* and *return* keywords.

Draw onscreen using digital pen: Drawing is used to cue attention to important phrases from a sentence while explaining that phrase. See slide instance at 3:13 in Table 7.9, instructor highlights the phrase ‘set of instructions’ to cue attention of learner.

Attention cueing was achieved with the help of onscreen annotation to demonstrate the control flow of the program during hand execution of the program. Figure 7.8 shows one such instance, notice the arrows on right side of the screen to show which line is being executed currently. Drawing other than arrows are not attention cue in Figure 7.8, as those are the content itself.

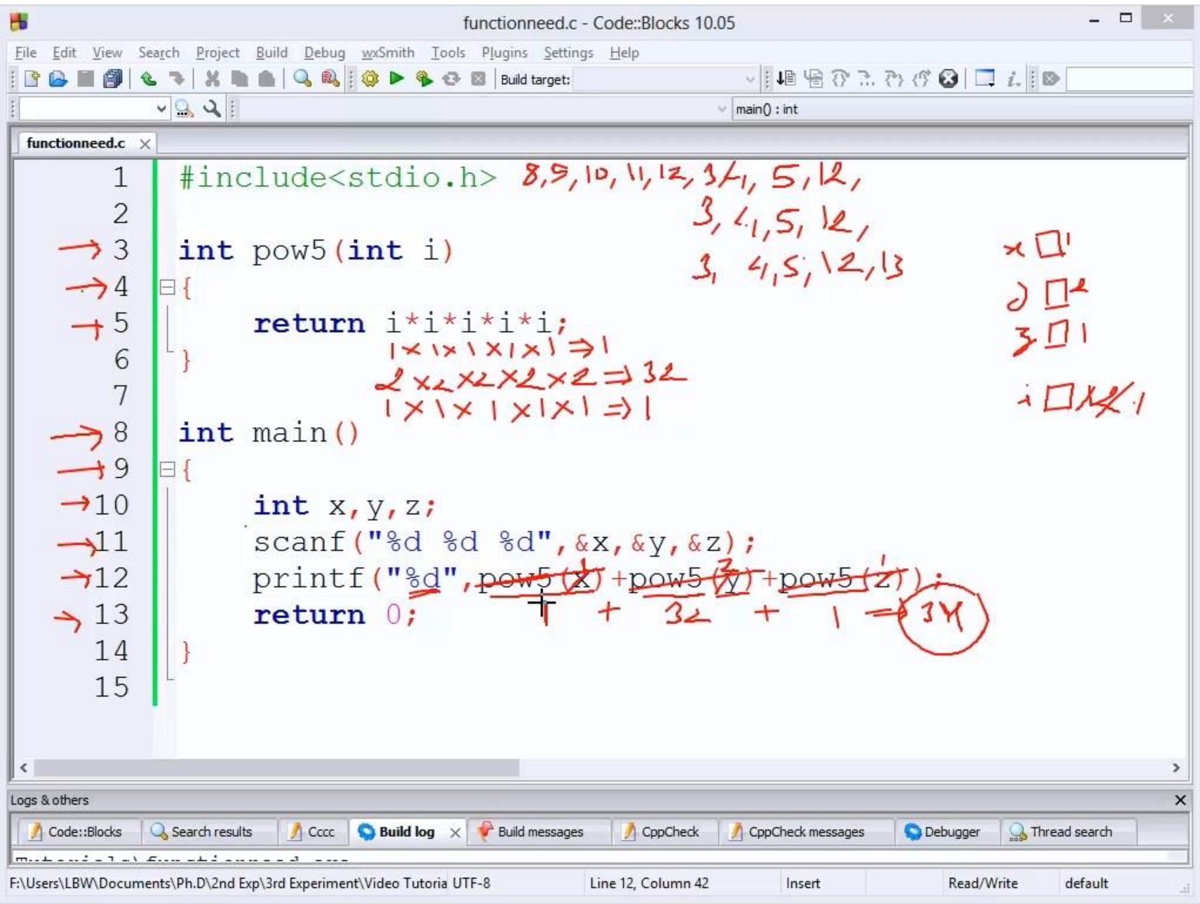


Figure 7.8 Attention cueing with draw on screen

Slides and source-codes created for this research cycle are presented in Appendix II and Appendix III respectively.

7.2.4. Research design

We created learning material in English for six days classroom based face-to-face instructions on introductory programming. We chose a reputed engineering college that had a mix of students from English and Hindi medium schools. We created three groups of students. The control group (HEc) had Hindi medium students attending the classroom in English. The experimental group (HHc) had Hindi medium students attending the Hindi classroom. As a baseline group (EEc), we had English medium students also attending the English classroom. Here, Hindi classroom is the one where verbal explanation of the content will be in Hindi MoI. The written learning material like slides, source-codes, compiler's interface etc. are in English for all groups.

7.2.4.1. Sample

The sample consisted of 105 undergraduate students of engineering first year of North India. The sample was divided into three groups according to their prior medium of instruction and medium of instructions in the treatment (MoI), as shown in Table 7.10.

Table 7.10 Medium of Instructions for various groups

Medium in K-12	MoI	Group	N
Hindi	Hindi	HHc (Experimental)	35
Hindi	English	HEc (Control)	35
English	English	EEc (Baseline)	35

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.

7.2.4.2. Instruments and Data Collection

To measure programming ability, performance scores on a post-test were collected every day. To determine prior knowledge of programming a 10-item pre-test was conducted. Pre-test and post-test used in this research cycle are given in Appendix IV. Overall percentage of marks in 12th grade final examination were collected to determine prior academic achievement levels.

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 created one post-test for every day of workshop 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 instructions. 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. Complete post-test for each day is given in Appendix IV. One sample post-test question from each category is given in Table 7.11.

Table 7.11 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 ....

7.2.4.3. Procedure

Survey: We first conducted the survey and then divided the students into three groups, based on the medium of their 12th Std, as shown in Table 7.10. We compared the means of the 12th standard 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 from the group, all the 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: Two separate colleges were chosen and students of HEc & EEc groups were taking classes together while HHc group was taking classroom in other college. Classroom was equipped with a computer and digital-pen & projector was attached with it.

Treatment: Teacher was giving instructions while students were watching and listening to the teacher. Students were allowed to make notes and ask questions. Class duration was one hour fifteen minutes long. There were no additional tutorials or laboratory exercises. The topics of each day are listed in Table 2.5.

7.3.Evaluation phase

The mean of post-test scores (out of 59) for the three groups (HHc, HEc and EEc) are shown in Table 7.12. From Table 7.12, the mean of scores for HHc and EEc group is higher than HEc group. HEc group is the lowest performer while HHc group outperform other two groups.

Table 7.12 Mean of post-test scores for all groups

Group	N	Mean	Std. Deviation	Std. Error of Mean
HHc	35	43.14	7.781	1.315
HEc	35	27.86	8.229	1.391
EEc	35	42.00	8.578	1.450

The distribution of the percentage of post-test scores for all three categories of questions (fact, process and concept) of the three groups (HHc, HEc and EEc) is presented in Table 7.13 and graphically represented in Figure 7.9. From Table 7.13 and Figure 7.9 we can say that for all categories of questions-

- HHc group outperformed other two groups (HEc and EEc). This difference was statistically significant for HHc vs HEc, while it was not so for HHc vs EEc.
- HEc group is the lowest performer among all the groups.

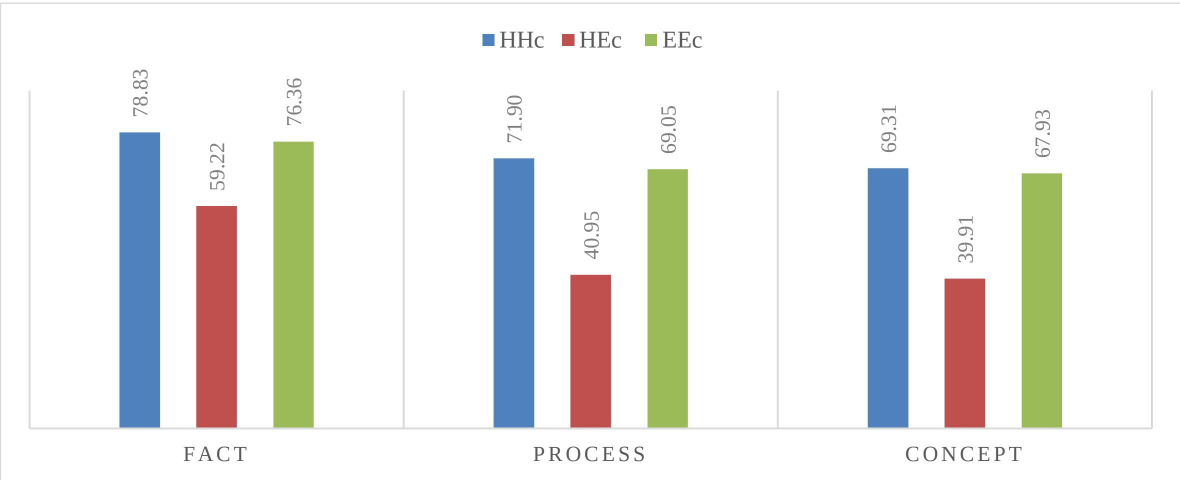


Figure 7.9 Percentage of post-test scores in each category for all classroom groups

Table 7.13 Percentage of post-test scores in each category for all classroom groups

	Fact	Process	Concept
HHc	78.83	71.90	69.31
HEc	59.22	40.95	39.91
EEc	76.36	69.05	67.93

7.3.1.1. Comparison of HHc and EEc groups

We performed one-way ANOVA (Glass & Hopkins, 1970) 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 7.14. This is an important result as this shows that the classroom teaching was identical in everything except the language of vocal explanation. It also confirms the perception of Hindi medium students who use of English MoI for on-screen text with the use of Hindi MoI for verbal explanation will not decrease their performance. Although this is a type of bilingual education where English and Hindi both MoI are being used to teach Hindi medium students but the use of English only in written material might not lead to English proficiency. So, in next research cycle we should plan instructions where more English MoI is used and test its effectiveness.

Table 7.14 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

7.3.1.2. Comparison of HHc and HEc groups

We performed one-way ANOVA (Glass & Hopkins, 1970) 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 7.15. This shows that Hindi medium students perform significantly low in a face-to-face classroom environment if MoI of verbal explanation is English even if the instructions are designed and presented to reduce the cognitive load.

Table 7.15 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

7.4.Problem resolution phase

Our treatment of teaching programming in classroom using the learning material created to reduce cognitive load of vernacular medium students by following multimedia principles and best practices of computer programming teaching in English versus Hindi, shows significant difference (p-value =

0.000) between total post-test scores of HHc, HEc and EEc group. It shows that MoI plays an important role in teaching programming.

Within the classroom environment, the difference between HHc and EEc is not statistically significant (Table 7.14). This is as expected since MoI for these groups was same as medium of their K-12 study. It shows that the language of instruction does not matter when MoI is matched with medium of K-12. This also confirms that the classroom teaching was identical in everything except language of vocal explanation.

The difference between HHc and HEc groups is statistically significant with effect size 0.69 (Table 7.15), showing that primary language learners are at a disadvantage when MoI is not matched with their medium of K-12. One possible reason for this is the problems of classroom environments as reported in literature, presented in Section 2.4. Classroom environment has some distractions like distance from instructor, peers sitting next to each other etc. It is also being reported that students want to take notes of everything in a classroom to study later so they focus more on taking notes than comprehending the lesson. Inability to concentrate after 20 minutes is also reported in literature. These distractions make it more difficult for comprehending lesson for vernacular medium learners who are studying in English language as they have to understand the content and language at the same time (John L. FaLconer J. Will Medlin, and Michael P. Holmberg, 2009).

We observe that the students were getting distracted in the classroom environment for various reasons. Some students were facing difficulty in watching the projector from the distance as font size of source code and program output is relatively small compared to slide font. Class duration was one hour long and students were facing difficulty to concentrate after some time. Teacher was facing difficulty in matching the pace of every student and explaining very slowly. After the workshop EEc group complained about the slow classroom while HEc group complained about the fast pace of the classroom. Hence we decided to repeat the same intervention by changing the environment to self-paced screencast based environment.

We compared HHc and HEc groups and found significant difference in total post-test scores as well as fact, process and concept type questions. Facts were written in slides in English and teacher explained them in MoI of the respective group. In order to understand the fact, students have to either read the text from screencast and translate it into their primary language or listen to teacher carefully to make sense of the information. For both groups, the slide text was in English and hence both groups had to read-translate-understand the English sentences. However, since the explanation was in English for HEc group, they had greater difficulty in comprehension, as seen from the scores. This finding creates a requirement to scaffold English MoI when educational content is being presented in vocal explanation for vernacular medium students.

We explained process content type by live-coding (Gaspar & Langevin, 2007) method and annotating source-code using digital pen-tablet (Mock, 2004) with audio narration. Thus understanding process was more dependent on visual elements and less dependent on vocal explanations. Since students were able to observe the program writing process and the result of program execution. We were expecting that we will not see any significant difference in post-test scores for process category of questions as the dependency on the MoI will reduce but we found significant difference for process category, as shown in Table 7.15.

Similarly, we found significant difference in scores of concept type content. Learning of a concept involves learning the definition, identifying instances of the concept in programming problems, and discrimination with other concepts (R. Clark & Mayer, 2011). The impact of MoI on learning of concepts was expected, and seen.

Our treatment of teaching introductory programming in traditional classroom environment of English versus Hindi sets clear baseline for us. Now we can say that MoI of verbal explanation plays an important role in performance of Hindi medium students in classroom environment even when content is designed and presented to reduce the cognitive load.

Some reasons for the mean scores being low could be:

Classroom environment: It is difficult for students to be actively engaged in classroom environment continuously for one hour. Moreover, all the students had to listen to the teacher simultaneously, without any scope for learning at their own pace. Task of HE group was doubled as they needed to listen, translate and comprehend at the same time. HH group did not need to translate the content as it was being delivered in their primary language. Hence the actual learning for HE group, as measured by post-test scores, was lower than the HH group.

Scaffolds: It is also possible that the scaffolds integrated into learning material were not sufficient and we needed more scaffolds.

This helped us to plan next intervention. We could either identify more scaffolds via literature review or change the learning environment. Changing the learning environment seemed more promising to solve the problem of vernacular medium students because of the following reasons:

1) In qualitative study, presented in section 2.2, students preferred self-study environment over classroom environment and preferred videos over books for self-study.

2) In RC2 and RC3 students reported several problems in the content and its presentation in screencasts but accepted that screencasts were useful for them.

Based on these findings we decided to repeat the same experiment for screencast based self-paced learning environment in next research cycle.

7.4.1. Impact of scaffolding on learning

Simple English MoI for on-screen text: the usefulness of this scaffold is confirmed for classroom environment in this research cycle. Hindi medium students performed equivalent to English medium students while the written text was presented in English MoI and verbal explanation of the text was done in Hindi MoI.

Simple English MoI for on-screen text: This finding is confirmed in RC4 when on-screen text was presented in English MoI with simple general English words and Hindi medium students performed equivalent to English medium students.

Use slow pace for vocal explanation: We tested this scaffold in this research cycle in classroom environment by maintaining slow pace while teaching in English MoI. We found that students performed poorly in post-test though the reason of students' poor performance was not yet clear. Hence we decided to keep using this scaffold for this research cycle also.

Cognitive scaffold: Pre-training, "visualization guidelines to teach various educational content", and "multimedia principles" are used to provide cognitive scaffold to students in this research cycle. We found that student's performance was satisfactory if the MoI of treatment was similar to student's MoI of K-12. But the performance of Hindi medium students receiving instructions in English MoI was significantly lower than other two groups. Although the reason of poor performance was not clear, we decided to use these principles for next research cycle.

Affective scaffold: We did not used self-study environment in this research cycle. This could be one of the causes of HE group's low performance. We decided to use self-paced study environment in the next research cycle.

7.5. Summary

In this research cycle we measured the actual effectiveness of the use of English MoI in classroom environment to teach programming with cognitively scaffolded educational content and presentation.

The main purpose of this research cycle was to get more insights to the need of scaffolds required for vernacular medium students. In this study, we found that using English MoI in written text and Hindi MoI for verbal explanation help Hindi medium students to comprehend the content and they perform equal to English medium students who received content in English MoI. We also found that Hindi medium students who learn content in English MoI in classroom environment perform significantly lower than other two groups. This leads to two findings, 1) more scaffolds are required to teach Hindi medium student in English MoI in classroom environment and 2) classroom environment is not a suitable environment for Hindi medium students even when content is presented and developed to reduce cognitive load. We decided to use screencasts based environment for vernacular medium students with the same scaffolds used in this cycle.

The summary of this research cycle is presented in Table 7.16 that shows the assumptions, actions and findings of this research cycle, actions for next research cycle, and guidelines for further research cycles. The problems of this RC are addressed in next research cycle (RC5) that is described in chapter 8.

Table 7.16 Summary of research cycle 4

Assumptions	**Actions**	**Findings**	**Actions for next RC**	**Recommendation for guidelines**
Vernacular medium students will face no difficulty in understanding written learning material in English if oral explanation is provided in Hindi in a classroom environment.	All written learning material was presented in English along with the Hindi explanation for one group (HHc) in classroom environment.	Vernacular medium students are able to comprehend the written English instructions if oral explanation is provided in Hindi in classroom environment.	Use English text along with verbal Hindi explanation in self-paced learning environment.	
Vernacular medium students will face difficulty in comprehending the learning content, if written text and oral explanation both are in English MoI in a classroom environment.	All written learning material was presented in English along with the English explanation for another group (HEc) in classroom.	Vernacular medium students performed poorly when written and oral both instructions were provided in English MoI in classroom environment.	Use English in written educational content along with verbal explanation in English MoI in self-paced learning environment.	

		MoI plays an important role in learning programming in classroom environment.		
Use of simple general English words will help in understanding educational content presented in English MoI in classroom environment.	Use simpler English words rather than complex.	Only use of simple English words is not sufficient to teach vernacular medium students in classroom environment.	Use simple English words in self-paced learning environment to teach vernacular medium students.	
Explaining subject-specific and semi-specialized words on first occurrence will help them to comprehend the learning material presented in English MoI.	All subject-specific and semi-specialized words were explained in detail on first occurrence.	Explaining subject-specific and semi-specialized English words in detail is not sufficient in teaching vernacular medium students in classroom environment.	Explain subject-specific and semi-specialized English words on first occurrence in self-paced learning environment.	
Use of slow pace for vocal explanation in English MoI will help vernacular medium students to comprehend English MoI in classroom environment.	Slow pace is used for vocal explanation.	Only use of slow pace for vocal explanation is not sufficient to teach vernacular medium students in classroom environment.	Use slow pace for vocal explanation in self-paced learning environment.	
Instructions created by following visualization guidelines and multimedia principles will help in learning in classroom environment.	Create instructions by following visualization guidelines and multimedia principles to teach vernacular medium student in classroom environment.	Well planned instructions alone are not sufficient to help vernacular medium student in comprehending educational content presented in English MoI in classroom environment.	Conduct literature review on the problems of classroom environment.	

		Classroom environment is not suitable to teach vernacular medium students.	Provide 1:1 self-paced learning environment to vernacular medium students.	Do not teach vernacular medium students in classroom environment.

Chapter 8

Research Cycle 5: using two languages in screencasts

In Chapter 7 details of fourth research cycle (RC4) are given in which we discussed treatment in classroom environment and found that classroom environment is not suitable for vernacular medium students with the scaffolds that we have used. This chapter presents the details of fifth research cycle (RC5) which was carried out to show if the scaffolds used in classroom environment work for screencast based self-study environment or not.

At a broad level, our question is RQ1: What is the impact of the MoI on the programming abilities of primary language learners in self-paced screencast based environment? This is operationalized into the following specific questions:

RQ5.1: Do undergraduate Hindi medium students, learning introductory programming by watching cognitively scaffolded screencasts in Hindi, perform better than similar students who watch the same screencast in English?

In order to determine which content types should be taught in Hindi and which content types could be taught in English using screencast, we had the additional question:

RQ5.2: What is the effect of MoI for varying content types in cognitively scaffolded screencast based programming instruction?

We also want to identify the impact of learning environment on student's performance. Hence the research question is: How does moving from classroom to screencast affect the performance of students? This is operationalized in the following question:

RQ5.3 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?

To test the impact of MoI on Hindi medium students in different environment, the research question framed is: How does medium of instruction affect the performance of primary language students, for both classroom and screencast? That is operationalized into following question:

RQ5.4: 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?

In section 8.1 we describe the need analysis phase where we try to resolve the problems of research cycle 4 (RC4) presented in Section 7.4. Design and develop prototype phase is presented in Section 8.2, in which we choose a research design to answer RQ5.1 and RQ5.2 and details of intervention provided to students. Section 8.3 of this chapter describes the evaluation methods used to measure the effectiveness of intervention. Section 8.4 of this chapter presents the problem resolution phase where we discuss the learnings and findings of fifth research cycle (RC5).

8.1.Need analysis phase

Some problems in the treatment given in classroom settings were visible, presented in Section 7.4, but no clear problem was visible in scaffold. Hence, we decided to test the similar scaffolds in screencast based self-study environment. We conducted research survey to identify the benefits of screencasts presented in Section 2.5.3.3. Detailed literature review about the classroom settings is reported in Section 2.4. Literature review on classroom settings revealed that classroom environment does not provide the self-paced instructions and teacher remains unable to match the pace of all students. Students do not learn in either case if pace is slower or faster than their pace. Hence, we decided to use self-paced learning environment for this research cycle.

Assumptions of this research cycle and corresponding actions taken in this research cycle are given in Table 8.1.

Table 8.1 Assumptions and actions of RC5

Assumptions	**Actions**
Vernacular medium students will face no difficulty to understand written learning material in English if oral explanation is provided in Hindi in a self-paced learning environment.	All written learning material was presented in English along with the Hindi explanation for one group (HHc) in self-paced learning environment.
Vernacular medium students will face difficulty in comprehending the learning content, if written text and oral explanation both are in English MoI in a self-paced learning environment.	All written learning material was presented in English along with the English explanation for another group (HEc) in self-paced learning environment.
Use of simple general English words will help in understanding educational content presented in English MoI in self-paced learning environment.	Use simpler English words rather than complex.
Explaining subject-specific and semi-specialized words on first occurrence will help them to comprehend the learning material presented in English MoI.	All subject-specific and semi-specialized words were explained in detail on first occurrence.
Use of slow pace for vocal explanation in English will help vernacular medium students to comprehend English MoI in self-paced learning environment.	Slow pace for vocal explanation is used.
Instructions created by following visualization guidelines and multimedia principles will help in learning in self-paced learning environment.	Create instructions by following visualization guidelines and multimedia principles to teach vernacular medium student in self-paced learning environmen

8.2. Design and develop prototype phase

8.2.1. Final prototype: cognitively scaffolded screencast in self-paced learning environment

Need analysis phase of this research cycle (Section 8.1) revealed the need for self-paced learning material for vernacular medium students. Hence we decided to use cognitively scaffolded screencasts in a self-paced learning environment for our next intervention prototype. In RC4, we didn't get any problem in the topics and learning material created in English MoI, so we didn't change any other setting.

Fifth prototype: Use of English as MoI in self-paced learning environment where student will watch the cognitively scaffolded screencast, created by following visualization guidelines to teach educational content types and presented by following the multimedia principles. Text on slides and source code is written in English. Teacher decided the sequence of video for each day and provided in a playlist.

We wanted to test the impact of the learning environment Hence subject, topics and instructional content were similar to those of previous research cycle. We changed the treatment for this intervention to screencast based self-paced learning environment. Screencasts for this research cycle were created with the scaffolds presented in previous sections (Section 8.2.2), we call such screencasts, cognitively scaffolded screencast. Details of fifth prototype is given in Table 8.2.

Table 8.2 Details of fifth prototype

Elements of intervention	**Details of final prototype**
Subject	Computer programming
Topic	• Topics from ACM CS curricula 2013: one knowledge unit. • Contains a mix of programming concepts, facts, processes, procedures and principles.
Instructional Content	Screencast recorded with the learning material prepared using best practices of computer science teaching and visualization guidelines.
Treatment	• 6 day workshop • Use of screencast • Self-paced learning environment

8.2.2. Scaffoldings used in fifth prototype

In this section we present the details of scaffoldings used in this research cycle (RC5). These scaffoldings are categorized into language-based scaffold, cognitive scaffold and affective scaffold.

8.2.2.1. Language-based scaffolds

We used two types of screencasts in this research cycle 1) recorded in English MoI and 2) recorded in Hindi MoI. Language based scaffoldings used in both types of screencasts are different. Table 8.3 presents the details of scaffolds for Hindi screencasts and Table 8.4 presents the details of English screencasts.

Language-based scaffolds in Hindi screencast

Simple English MoI for on-screen text (Table 8.3, point 1): The usefulness of this scaffold is confirmed for classroom environment in RC4 when Hindi medium students perform on par with English medium students while the written text was presented in English MoI and vocal explanation of the text was done in Hindi MoI. We are using this scaffold in this research cycle to test its actual effectiveness in screencast based self-paced learning environment. This scaffold is provided for both English and Hindi screencasts.

Hindi MoI for vocal explanation (Table 8.3, point 2): In previous research cycle (RC4) we used Hindi MoI for vocal explanation in face-to-face classroom environment. This scaffold is found useful as HHc group performed similar to EEc group in post-test. Hence, we decided to use this scaffold in this research cycle.

Use general Hindi words if vocal explanation is Hindi (Table 8.3, point 3): We used this scaffold in RC3 and RC4 and found it useful. In this research cycle we are using it for screencast based self-paced environment.

Specialized and semi-specialized words in English (Table 8.3, point 4): In RC4 we used this scaffold in classroom environment and found it useful. We are using it for this research cycle.

Code-switching (Table 8.3, point 5)**:** We used code-switching in RC3 and RC4 for screencast and classroom when Hindi MoI is used. The usefulness is confirmed by qualitative study (RC3) and quantitative study (RC4). We decided to use this for this research cycle as scaffold for vernacular medium students.

Explain specialized and semi-specialized terms in detail on its first occurrence (see Table 8.4, point 6). The need for this scaffold was identified in RC2 and implemented in RC3, content analysis of questions generated by students shows the usefulness of this scaffold. We used this scaffold in RC4 also and again find it useful. So, we decided to use this scaffold for this research cycle.

Table 8.3 Details of language-based scaffoldings used in Hindi screencasts

No.	Detail of scaffolding in Hindi screencast	Where to use
1	Simple English MoI for on-screen text	On-screen text
2	Use Hindi MoI	Vocal explanation
3	Use general Hindi words if vocal explanation is Hindi	Vocal explanation
4	Specialized and semi-specialized word in English	Vocal explanation, On-screen text
5	Code-switching	Vocal explanation
6	Explain specialized and semi-specialized words on first occurrence	

Language based scaffolds in English screencasts

Scaffolds used in English screencasts are different from the scaffolds used in Hindi screencasts. Details of scaffolds used in English screencasts is given in Table 8.4.

Use slow pace for verbal explanation (see Table 8.4, point 4): We tested this scaffold in RC4 in classroom environment by maintaining slow pace while teaching in English MoI. We found that students performed poorly in post-test. Though the reason for student's poor performance was not yet clear, we decided to keep using this scaffold for this research cycle also.

Table 8.4 Details of language-based scaffoldings used in English screencasts

No.	Detail of scaffolding in English screencast	Where to use
1	Use general English words while using English MoI.	Vocal explanation, On-screen text
2	Explain specialized and semi-specialized terms in detail on its first-occurrence.	
3	Specialized and semi-specialized words in English	On-screen text
4	Use slow pace for verbal explanation	Vocal explanation

8.2.2.2. Cognitive scaffolds

Cognitive scaffolds are provided by segmentation, pre-training, and "visualization guidelines to teach various educational content types" and "multimedia principles". In RC4 segmentation was not used and use of other three cognitive scaffolds shown to be effective for HHc group. Cognitive scaffolds used in this research cycle are listed in Table 8.5. Multimedia principles of content presentation for this research cycle are listed in Table 8.6.

Table 8.5 Details of cognitive scaffolds in final prototype

No.	**Detail of cognitive scaffolding**	**Type of cognitive load it reduce.**
1	Segmentation and pre-training	Intrinsic
2	Create content using “visualization guidelines to teach educational content".	Intrinsic
3	Present content using "multimedia principles”.	extrinsic

Table 8.6 Multimedia principles of educational content presentation to reduce cognitive load

No.	**Multimedia principles to reduce cognitive load**	**Type of cognitive load it reduce.**
1	Split-attention effect	Extrinsic
2	Redundancy effect	Extrinsic
3	Verbal redundancy	Extrinsic
4	Synchronization	Extrinsic
5	Attention cueing	Extrinsic

8.2.2.3. Affective scaffold

We provide affective scaffolding similar to RC2 and RC3, i.e. screencast based self-paced learning environment (Table 6.7). This scaffold was not used in RC4.

Table 8.7 affective scaffolding used in third prototype

No.	**Detail of affective scaffold**
1	Screencast based self-paced learning environment

8.2.3. Design of learning material

8.2.3.1. Similarity and difference from previous research cycle

Slides, source code, examples used to explain the content, instructions used in this research cycle are all similar to previous research cycle (RC4). Slides and source-code used to record screencasts are given in Appendix II and Appendix III respectively.

One scaffold ‘segmentation’ is used in this research cycle but not in previous research cycle. Segmentation can be provided in student controlled environment only. In segmentation, content is divided into multiple small chucks and students can view them according to their need.

The screencasts are different in terms of time used to teach a topic. Classroom based intervention was taking around one hour every day while the maximum length of screencast was 45 minutes. Topics and corresponding content type (fact, process, concept, procedure, principle) covered in screencasts for each day were similar to the previous research cycle. Time taken to teach each topic and its content type are presented in Appendix V and its visual representation is presented in Figure 8.1. Segments details of first day programming workshop is given in Table 8.8, which presents the detail of topics, content types and time to teach the topic. For example, topic "computer" is a concept and its teaching time started from 00:00:10 second and ended at 00:02:58 second. The topics listed as major start time shows the segments. The portion between two dotted vertical lines is a segment (see Figure 8.1). Minor time is showing a topic that is required to teach with some major topic. For example, "How to write a computer program" is a procedure. While teaching this content, we also teach the minor topics; "interface of code::blocks compiler" and "How to write and compile a program in code::blocks".

Table 8.8 Topics covered in screencast of first day treatment

Major Start Time	minor start time	minor end time	Major end time	Content Type	Topics to teach
00:00:10			00:02:58	Concept	Computer
00:02:58			00:03:54	Concept	Computer Program
00:03:54			00:15:35	Procedure	How to write a computer program
	00:10:24	00:11:32		Procedure	Interface of code::blocks compiler
	00:12:07	00:15:33		Procedure	How to write and compile a program in code::blocks
00:15:33			23:22	Process	How does a program compile
00:23:22			00:24:09	Fact	C character set
00:24:09			00:28:14	Concept	Escape sequence
	00:25:37	00:28:11		Procedure	How to use /n /t in computer program

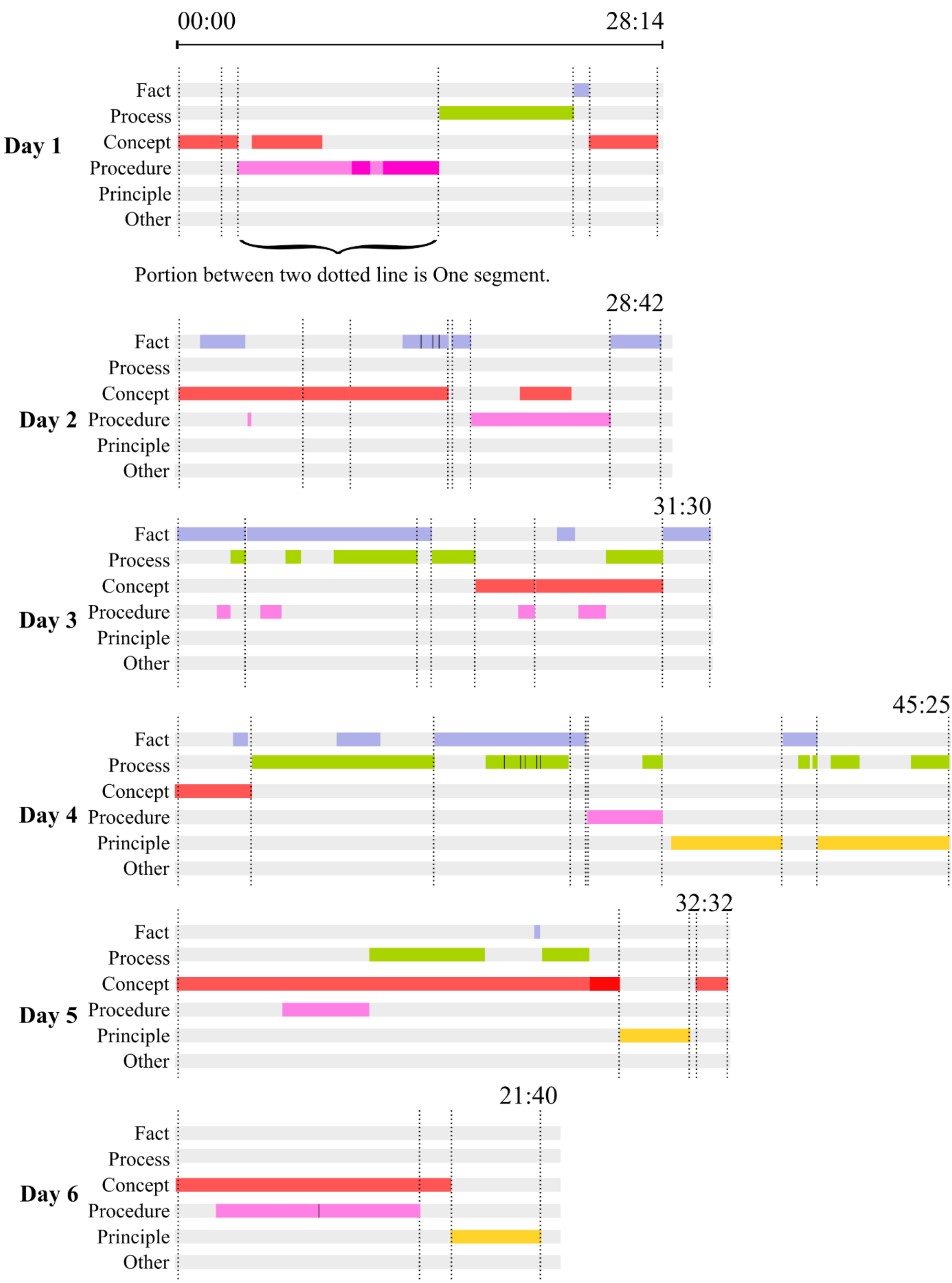


Figure 8.1 Visual representation of timelines of various content types used in RC5

8.2.4. Research design

We created six playlists of screencasts on introductory programming, in English and Hindi. We chose a reputed engineering college that had a mix of students from English and Hindi medium schools. We created three groups of students. The control group (HEs) had Hindi medium students watching the screencasts in English. The experimental group (HHs) had Hindi medium students watching the corresponding Hindi screencasts. As a baseline group (EEs), we had English medium students also watching the English screencasts.

8.2.4.1. Sample

The sample consisted of 105 first year undergraduate engineering students of North India. The sample was divided into three groups according to their prior medium of instruction and medium of instructions in the treatment (MoI), as shown in Table 8.9.

Table 8.9 Medium of Instructions for various groups

Medium in K-12	**MoI**	**Group**	**N**
Hindi	Hindi	HHs (Experimental)	35
Hindi	English	HEs (Control)	35
English	English	EEs (Baseline)	35

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.

8.2.4.2. 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 created one post-test for every day of workshop 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 8.10. All pre-test and post-test questions used in this research cycle are presented in Appendix V.

Table 8.10 Sample post-test questions from each category

Checking knowledge of	Sample Question
Fact	**Q16. Match the following** Relational Operator % Equality Operator >= Unary Operator = Arithmetic Operator == Assignment Operator ++

Process	**Q3. What will be the output of following program?**
	`#include<stdio.h>`
	
	`int main()`
	`{`
	`    printf("One\tTwo");`
	`    return 0;`
	`}`
	a. One\tTwo
	b. One
	Two
	c. One Two
	d. None of the above

Concept	**Q8. Value of K if?** **K = 5 == 6** a. 6 b. 5 c. 0 d. 1 e. Other please write ……………………………………

8.2.4.3. Procedure

Survey: We first conducted the survey and then divided the students into three groups, based on the medium of their 12th Std, as shown in Table 8.9. We compared the means of the 12th standard 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 eliminated all the 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: We arranged separate computer labs for the three groups. Each computer was equipped with headphone and media player was installed on each computer in advance.

Treatment: Each student was allotted one computer. Each student watched screencast on the allotted computer in computer lab. Each computer was equipped with headphone so that students cannot hear outside noise. Students were allowed to continuously watch screencast for 50 minutes. They were free to use video player controls according to their need. Students needed to watch screencasts every day in the sequence decided by teacher. Screencast for each day was combined in a playlist. Shortest screencast playlist is 22:00 minutes in length and longest screencast length is 45:00 minutes. There were no additional tutorials or laboratory exercises. The topics of the screencast of each day is listed in Table 2.5.

8.3. Evaluation phase

The mean of post-test scores (out of 59) for the three groups (HHs, HEs and EEs) are shown in Table 8.11. From Table 8.11, the mean of scores for HHs and EEs group is higher than HEs group. HEs group is the lowest performer while HHs group outperformed other two groups.

Table 8.11 Mean of post-test score in each group

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

The distribution of percentage of post-test scores for all three categories of questions (fact, process and concept) of the three groups (HHs, HEs and EEs) is presented in Table 8.12 and graphically represented in Figure 8.2. From Table 8.12 and Figure 8.2 we can say that for all categories of questions-

- HHs group outperformed other two groups (HEs and EEs). This difference was statistically significant for HHs vs HEs, while it was not so for HHs vs EEs.
- HEs group is the lowest performer among all groups.

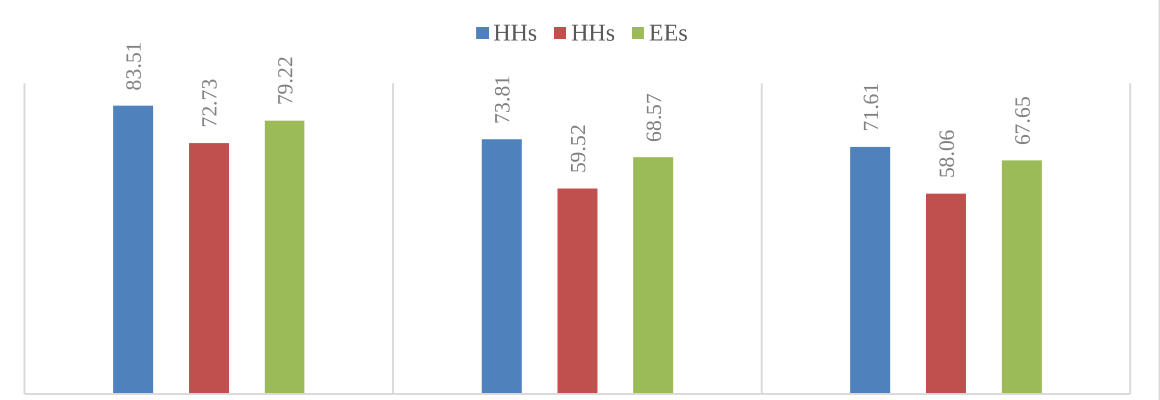


Figure 8.2 Percentage of post-test scores in each category for all groups

Table 8.12 Percentage of post-test scores in each category for all groups

Group	Fact	Process	Concept
HH	83.51	73.81	71.61
HE	72.73	59.52	58.06
EE	79.22	68.57	67.65

8.3.1.1. Comparison of HHs and EEs groups

We compare the performances of HHs and EEs groups as we expect that there will be no significant difference in post-test scores in total score as well as in each category of questions. We performed one-way ANOVA (Glass & Hopkins, 1970) and found no significant difference in the post-test scores for any question category, as shown in Table 8.13. This confirms that screencasts are effective for both, Hindi medium students and English medium students if MoI is similar to their MoI in K-12.

Table 8.13 One-Way ANOVA for HHs and EEs groups

		Sum of Squares	df	Mean Square	F	Sig.
Fact	Between Groups	15.557	1	15.557	2.088	.153
Process	Between Groups	1.729	1	1.729	1.012	.318
Concept	Between Groups	26.414	1	26.414	1.586	.212
Total	Between Groups	108.129	1	108.129	2.509	.118

8.3.1.2. Comparison of HHs and HEs groups

We compare HHs and HEs groups as we expect that there will be significant difference in post-test scores in total score as well as in each category of question. We performed one-way ANOVA (Glass & Hopkins, 1970) and found significant different in total score as well as in fact, process and concept question categories, as shown in Table 8.14. This confirms the effect of MoI in screencast based environment as Hindi medium students learning from English MoI using screencasts perform significantly lower than those who were learning from Hindi MoI using screencasts.

Table 8.14 One-Way ANOVA for HHs and HEs groups

		Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Fact	Between Groups	98.41	1	98.41	12.62	.001
Process	Between Groups	12.86	1	12.86	7.10	.010
Concept	Between Groups	308.70	1	308.70	21.88	.000
Total	Between Groups	965.72	1	965.71	21.21	.000

8.3.2. Analysis across RC4 and RC5

We want to measure the difference in post-test scores when learning environment changes.

8.3.2.1. Screencast vs classroom

In order to investigate the difference between the environment in which intervention was provided we compare the results from research cycle 4 (Chapter 7) with the result of this cycle. Mean of scores for HHc group and the EEc group is higher than the HEc group (see Table 7.12), and the mean of scores for the HHs and EEs group is higher than the HEs group (see Table 8.11). This indicates that for both environments Hindi medium students who get the treatment in English MoI performed lower than other students. HHc, HEc and EEc group perform lower than HHs, HEs and HEs respectively in each category of question (see Figure 8.3, Figure 8.4 & Figure 8.5). 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 8.3, Figure 8.4 and Figure 8.5 respectively.

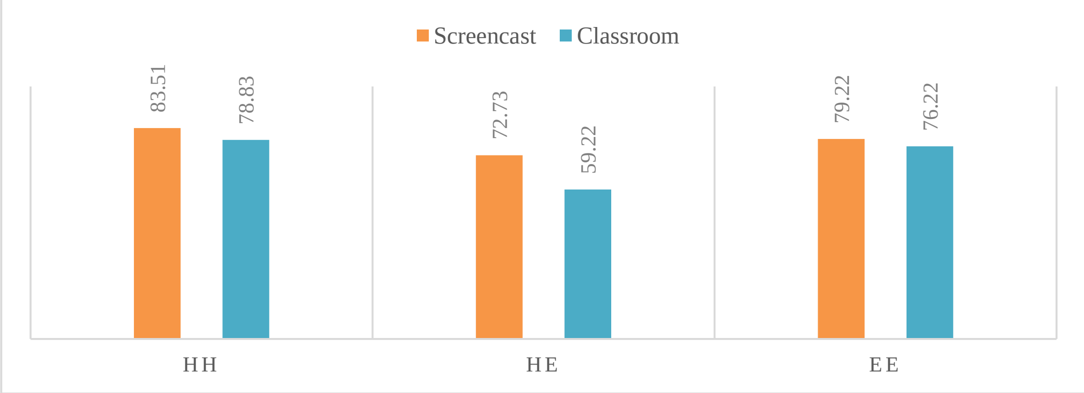


Figure 8.3 Percentage of post-test scores of fact type questions

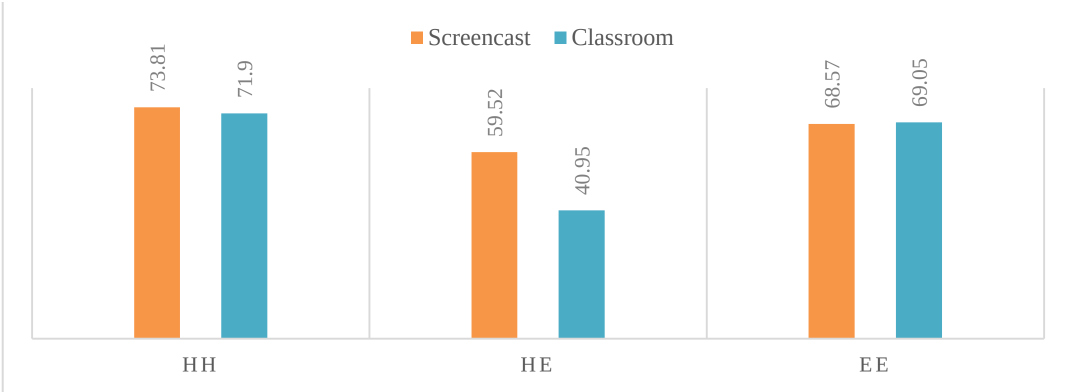


Figure 8.4 Percentage of post-test scores of process questions

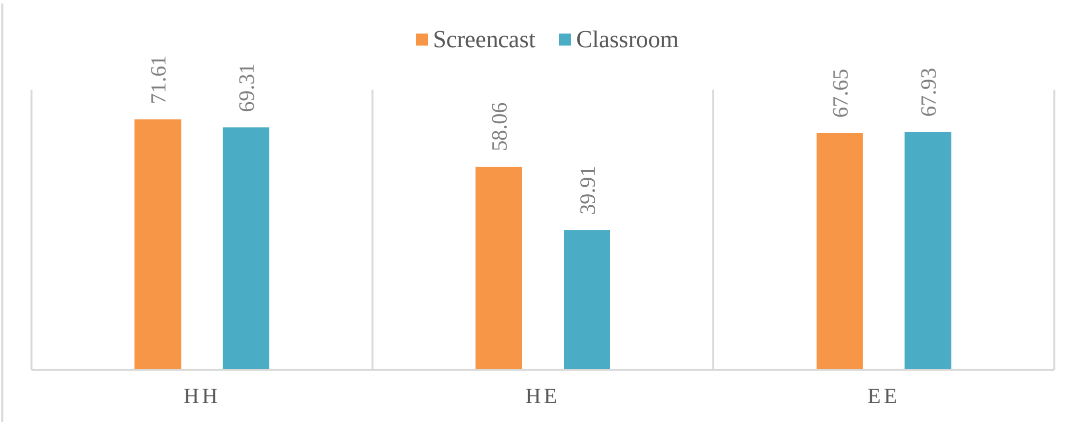


Figure 8.5 Percentage of post-test scores of concept questions

Comparison of HHc and HHs groups

We performed one-way ANOVA (Glass & Hopkins, 1970) 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 8.15. This shows that learning environment has no significant effect on the learning of Hindi medium students when treatment was given in Hindi MoI.

Table 8.15 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

Comparison of EEc and EEs groups

We performed one-way ANOVA (Glass & Hopkins, 1970) 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 8.16. This shows that learning environment has no significant effect on the performance of English medium students when treatment was given in English MoI.

Table 8.16 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

We can also say that learning environment has no significant difference on student's performance when MoI in treatment is similar to MoI in K-12.

Comparison of HEc and HEs groups

We compare HEc and HEs groups by performing one-way ANOVA (Glass & Hopkins, 1970) and found statistically significant difference in total score (effect size 0.56) as well as in all three question categories, as shown in Table 8.17. This result shows that the learning environment has significant effect on the performance of if there is mismatch in MoI of treatment and MoI in K-12.

Table 8.17 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

The comparisons presented in this section conclude that learning environment is a significant factor while teaching vernacular medium students. Screencast based self-paced learning environment is significantly better that classroom environment for vernacular medium students. From the comparison of RC4 and RC5, we can conclude that the scaffolds (cognitive and language-based) are ineffective in classroom environment while the same scaffolds are effective in screencast based self-paced learning environment. More discussion on this is presented in next section 'problem resolution phase'.

8.4.Problem resolution phase

Our treatment of teaching programming using screencast in English versus Hindi, shows significant difference (p-value = 0.000) between total post-test scores of HH, HE and EE group. It shows that MoI plays an important role in teaching programming in screencast based self-paced learning environment.

We compared HHs and EEs groups and found no significant difference. This is as expected since MoI for these groups was same as MoI of their K-12. This also confirms that the screencasts were identical in everything else, except the language of vocal explanation.

We compared HHs and HEs groups and found significant difference in total post-test scores as well as fact, process and concept type questions. Facts were written in slides in English and teacher explained them in MoI of the respective group. In order to understand the fact students have to either read the text from screencast and translate it into their primary language or listen to teacher carefully to make sense of the information. For both groups, the slide text was in English and hence both groups had to read-translate-understand the English sentences. However, since the explanation was in English for HEs group they had greater difficulty in comprehension, as seen from the scores.

We explained process content type by live-coding (Gaspar & Langevin, 2007) method and annotating source-code using digital pen-tablet (Mock, 2004) with audio narration. Thus understanding process was more dependent on visual elements and less dependent on vocal explanations. As students were able to observe the program writing process and the result of program execution. We were expecting that we will not see any significant difference in post-test scores for process category of questions as the dependency on the MoI will reduce but we found no significant difference for process category.

Similarly, we found significant difference in scores of concept type. Learning of a concept involves learning the definition, identifying instances of the concept in programming problems, and discrimination with other concepts (R. Clark & Mayer, 2011). The impact of MoI on learning of concepts was expected, and seen.

From Figure 8.3, Figure 8.4 & Figure 8.5, we observe that the performance of HEc group is the lowest among all the groups, while HHs group is the highest performer, for all categories of questions. This reconfirms the fact that classroom based instruction in English is not suitable for primary language learners. On the other hand, while classroom based instruction in primary language is suitable, self-paced screencasts in primary language lead to maximum performance.

For both settings (classroom and screencast), we conclude that primary language learners perform comparable to English medium learners, when they continue to learn in their primary 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 8.15), and the difference between EEc and EEs is also not significant (Table 8.16). This leads to the conclusion that the environment (classroom versus screencast) does not play a role in performance if MoI in treatment and 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 8.17). This indicates that when MoI of treatment is different from MoI of K-12, the environment plays a role in the performance. Thus we conclude that if MoI is mismatched for primary language learners, then it is better to use self-paced screencast rather than a classroom setting.

8.4.1. Impact of scaffoldings on learning

In this research cycle we found that the mix of language based scaffolding, cognitive scaffoldings and affective scaffolding helps students to gain content knowledge using English MoI. Using the scaffoldings to teach vernacular medium students in English MoI in this research cycle answer our main research question. **"How to scaffold a vernacular medium student within the limitations of practical context to achieve the goals of bilingual education?"**

Using English only MoI in screencasts leads to satisfactory performance of students while using both languages (bilingual MoI) in screencasts leads to maximum performance of the students. Teaching vernacular medium students in English only MoI has more probability to improve the English competency of students and the performance is also satisfactory. Hence, we decided to prefer English only MoI in a screencast based self-paced environment over Bilingual MoI in classroom or screencast based environment.

8.5.Summary

In this research cycle we used cognitive and language-based scaffoldings to develop and present educational content. In previous research cycle we used same scaffoldings to develop and present content. Only difference between these two research cycles was the difference of learning environment. In RC4 we used classroom based environment and found that the scaffoldings given to students do not have any impact on student's performance in post-test scores and HEc group performed significantly lower that other two groups. In RC5 we used screencast based environment and found significant improvement in the performance of Hindi medium students when content is delivered in English. The mean score of HEs group (37.57 out of 59, i.e. 63.67%) is acceptable to pass with first division in the university exam. The mean score of HEc group (27.86 out of 59, i.e. 47.22%) is not acceptable by university and student needs to give re-exam to qualify the subject. We also found the difference of post-test scores for HEc and HEs group to be significant. This result answer our main question: **"How to scaffold a vernacular medium student within the limitations of practical context to achieve the goals of bilingual education?"**

The goals of bilingual education for this study is 1) Students will be able to understand the concepts better, 2) Students will be more proficient in the second language.

First goal, "students will be able to understand the concept better" is achieved in screencast based self-study environment where English MoI is used with the cognitive and language-based scaffolds, Hindi medium students are performing significantly better than those who are studying in classroom environment and student's performance is comparable to university standard.

This intervention creates a CLIL (Content and Language Integrated Learning) program for Hindi medium students as they learn programming using English MoI. In a qualitative study conducted by Yang, he found that student's receptive competency increases with time in a CLIL environment (Yang, 2015). He found that students do not face problems related to English MoI in second semester if taught in a CLIL environment. Use of English MoI in learning material and verbal explanation will help in developing English competency and students will be able to comprehend the learning material provided in English MoI without the scaffoldings with the time. This will help in completing second goal of bilingual education "make learners more proficient in second language"

This intervention can be provided within the "limitations of practical context". Limitations of practical context to provide scaffolding to vernacular medium students was identified as 1) limited time to provide intervention, 2) assessment in English, 3) English major classroom and 4) Non-availability of primary language learning material. Below we show how these limitations can be addressed by the intervention given in this research cycle.

Limited time to provide intervention: The intervention in this research cycle is using cognitively scaffolded screencast in a self-paced environment. Cognitive and language-based scaffolds were embedded in the screencast. Same instructions were given in the classroom environment in RC4 by same teacher using same slides, source-code and examples for six days. While the longest classroom session (4^{th} day) takes 75 minutes to complete screencast for same day (4^{th} day) is 45 minutes 25 seconds long only and students take 55-60 minutes to watch screencast. In classroom environment HEc group perform poorly while in screencast environment HEs group perform significantly better than HEc group. Based on these findings we can say that students comprehend learning material in relatively less time in screencast based self-paced study than classroom environment.

Exam and assessment in English: Teachers recommended not to use Hindi MoI to teach vernacular medium students, in a qualitative study presented in RC2. Teachers believed that students learning from Hindi only MoI will not be able to pass the exams that will be in English because use of Hindi only MoI will not help to gain English proficiency. The intervention, provided to students in this research cycle use English only MoI with language-based scaffolds and students attempted English post-test every day after the treatment. Hindi medium students did not reported any problem in understanding a post-test provided in English. Use of English MoI only instructions to teach programming will improve English proficiency of students (Yang, 2015) and students will not face difficulty in understanding exam paper written in English.

English major classroom: We are using the term "English major classroom" for a classroom where the number of English medium students is more than Hindi medium students. Students showed low confidence because of poor competency in English and accepted that this problem increased in English major classroom because of behaviour of peers that stopped them from participating in classroom discussions. This leads to further problems like students hesitating to ask questions if they did not understand or miss something. When student is learning from screencast he/she has chance to utilize the controls of video player (play, pause, repeat, forward, replay etc.) Thus, if they don't understand something they can use navigation bar to go back and listen to it again (Simpson, 2006). Screencast is watched in one to one mode and student has full control over it and student do not depend on teacher or peers so English major classroom is not a problem in receiving instructions in English.

Non-availability of primary language learning material: In the qualitative study presented in 2.2, students accepted that they prefer books in English MoI written by Indian authors because words used in these books are not as difficult as in books written by foreign authors. Students also reported that they preferred English-English dictionary over English-Hindi dictionary because sometimes meaning of English word in Hindi is either not available or the Hindi word is also unknown to them.

In RC2 students reported that use of Hindi words that are unknown to them is making it difficult to comprehend the instructions from screencasts. In RC3 students reported not to use Hindi MoI for on-screen text in screencasts. In RC4 and RC5, Hindi medium students performed similar to English medium students when on-screen text presented in English MoI. These findings from qualitative studies and quantitative studies confirm that this is not a problem for undergraduate students as they have studied English as a subject in K-12 and can understand from English MoI with appropriate scaffolds. In this research cycle (RC5), we found that this prediction is true when HEs group performed significantly better than HEc group.

As we can see that the interventions used in this research cycle answer our research question: "How to scaffold a vernacular medium student within the limitations of practical context to achieve the goals of bilingual education?" Use of appropriate scaffolds leads to satisfactory performance of vernacular medium students by achieving the goals of bilingual education within the limitations of practical context. Hence, we conclude this as a final research cycle for this thesis. Summary of this research cycle (RC5) is presented in Table 8.18.

Chapter 9 presents the scaffolding framework to teach vernacular medium students.

Table 8.18 Summary of fifth research cycle

Assumptions	Actions	Findings	Actions for next RC	Recommendation for guidelines
Vernacular medium students will face no difficulty in understanding written learning material in English if oral explanation is provided in Hindi in a self-paced learning environment.	All written learning material was presented in English along with the Hindi explanation for one group (HHc) in self-paced learning environment.	Vernacular medium students are able to comprehend the written English instructions if oral explanation is provided in Hindi in self-paced learning environment.		
Vernacular medium students will face difficulty in comprehending the learning content, if both written text and oral explanation are in English MoI in a self-paced learning environment.	All written learning material was presented in English along with the English explanation for another group (HEc) in self-paced learning environment.	Vernacular medium students performed significantly well when both written and oral instructions were provided in English MoI in self-paced learning environment compared to classroom environment.		Use of English MoI in written text and verbal explanation of educational content in self-paced learning environment help in comprehending the content.
		MoI plays an important role in learning programming in self-paced learning environment.		

Use of simple general English words will help in understanding educational content presented in English MoI in self-paced learning environment.	Use simpler English words rather than complex.	Use of simple English words in self-paced learning environment helps vernacular medium students in comprehending the learning content presented in English MoI.		Use of simple English words in self-paced learning environment helps in learning.
Explaining subject-specific and semi-specialized words on first occurrence will help them to comprehend the learning material presented in English MoI.	All subject-specific and semi-specialized words were explained in detail on first occurrence.	Explaining subject-specific and semi-specialized English words in detail in self-paced learning environment help vernacular medium to comprehend the presented content.		Explaining subject-specific and semi-specialized words on fist occurrence in self-paced learning environment helps in understanding English MoI.
Use of slow pace for vocal explanation in English will help vernacular medium students to comprehend English MoI in self-paced learning environment.	Use of slow pace for vocal explanation is used to present content in English.	Use of slow pace for vocal explanation helps vernacular medium students to comprehend the learning material presented in English MoI		Use of slow pace for vocal explanation in English MoI in self-paced learning environment helps in learning.
Instructions created by following visualization guidelines and multimedia principles will help	Create instructions by following visualization guidelines and multimedia	Instructions created by following visualization guidelines and multimedia principles help vernacular		

in learning in self-paced learning environment.	principles to teach vernacular medium student in self-paced learning environment.	medium students in comprehending educational content presented in English MoI in self-paced learning environment.		
		Self-paced learning environment itself acts as scaffold to teach vernacular medium students.		Self-paced learning environment act as scaffold for vernacular medium students.

Chapter 9

Scaffolding Framework to teach vernacular medium learners

This chapter presents all the scaffolds we identified, tested and selected/rejected during the research work. This chapter also presents the framework to teach vernacular medium students using these scaffolds. The framework has two parts, first part is useful to teach vernacular medium students in English only MoI and second part is useful to teach in bilingual MoI.

9.1. Identification of scaffolds

We identified and tested various scaffolds in each research cycles based on the literature review and findings of the intervention. Scaffolds identified in this thesis are hard scaffolds. Hard scaffold is a static support that can be planned in advance if student's difficulty is known (Brush & Saye, 2002). We planned each scaffold in advance after identifying the problems of students either from literature or findings from research cycles.

In our work, we identified and tested scaffoldings for first year undergraduate students because the problem of English MoI are reported in literature and accepted by students only in first year of the program(Yang, 2015). These scaffolds are used to develop educational content to teach programming to vernacular medium students.

We identified language-based, cognitive and affective scaffolding in this thesis. Details of each scaffold in given in this section.

9.1.1. Language-based scaffoldings

We identified and tested ten language-based scaffoldings to teach vernacular medium students in our experiment. The scaffoldings, useful to teach in English only MoI are listed in Table 9.1. Scaffoldings useful to teach in bilingual MoI are listed in Table 9.2. We rejected some scaffolds because of some shortcomings. These scaffoldings are listed in Table 9.3.

9.1.1.1. Language-based scaffoldings useful to teach in English only MoI

9.1.1.1.1. Use of simple English MoI for both on-screen text and vocal explanation:

This scaffold was first identified in qualitative analysis reported in Section 2.2 when students accepted the use of English-English dictionary. Students were using English-English dictionary to know the simple synonyms of complex English words. This fact is again identified in RC3 when students reported the shortcomings of using on-screen text and suggested to use English MoI for written English. This finding is confirmed in RC4 when on-screen text was presented in English MoI with simple general English words and Hindi medium students (learning with Hindi MoI) performed at par with English medium students. In RC5 we found this scaffolding useful for Hindi medium students learning in English MoI. We used simple synonyms of complex English words to provide this scaffold, for example “vary” is replaced with “change”.

9.1.1.1.2. Explain the specialized or semi-specialized word on its first occurrence

We identified the need of this scaffold in RC2 when students asked questions related to specialized words. When we analyzed the transcript of the selected screencast (Table 5.14) we found that instructor used few specialized terms (execute, compile, parameter etc.) in screencast without explaining them and students were facing problems in comprehending the learning material. We used this scaffold in next prototype (RC3) and students did not ask any question related to the meaning of specialized or semi-specialized vocabulary.

Specialized word will be new if student is learning the subject for the first time. In that case, it should be explained with the meaning, usage and examples. If the specialized word is new for the student but student knows its meaning in local language (this will happen if student has previously studied the subject in local language) then explain the meaning of the word with the help of equivalent local language term and elaborate its usage with examples. If the term is semi-specialized then explain it with the context of current subject using examples and usages. After giving special attention to specialized and semi-specialized terms on first occurrence these terms can be used in English on successive occurrences throughout the subject.

9.1.1.1.3. Use of slow pace for vocal explanation

We identified this scaffold in qualitative study conducted in RC2, when students and teachers reported the usefulness of slow pace used in selected screencast in RC2. We tested this scaffold in RC4 in classroom environment by maintaining slow pace while teaching in English MoI. We found that students performed poorly in post-test. We again tested this scaffold in screencast based self-paced scaffold in RC5. This time, students performed better than classroom based environment. The result of RC5 confirms that this scaffold is useful for vernacular medium student to learn in English MoI.

9.1.1.1.4. Use of English for specialized and semi-specialized words

We identified this scaffold in RC2 when students complained about the use of translated specialized words and suggested not to translate subject-specific words in Hindi. In RC3 we used transliteration of specialized and semi-specialized words, students reported it as a shortcoming in screencast. In RC4 we used English for these words for on-screen text and Hindi medium students performed at par with English medium students. We confirm this scaffolding in RC5 when vernacular medium students learning in English MoI performed well in post-test.

Table 9.1 Language based scaffoldings useful to teach in English only MoI

No.	Details of scaffolding	Where to use
1	Use of simple English MoI	Vocal explanation, On-screen text
2	Use of slow pace for vocal explanation	Vocal explanation
3	Explain specialized and semi-specialized vocabulary on first occurrence	
4	Use of Specialized and semi-specialized words in English	On-screen text, vocal explanation

9.1.1.2. Language based scaffoldings useful to teach in bilingual MoI

In our work, we found that language-based scaffoldings to teach in English MoI are effective only for self-paced learning environment. In a classroom setting use of two languages (bilingual education) with appropriate scaffoldings to teach vernacular medium students is found effective. These scaffoldings are listed in this section.

9.1.1.2.1. Use of simple Hindi MoI for vocal explanation

We identify this scaffold in RC2 when students complained about few difficult Hindi words used in screencasts in verbal explanation. We confirm this finding in RC3 when we used normal spoken Hindi and students did not complain about the use of spoken Hindi in screencasts. In RC4 and RC5 we used simple Hindi words for vocal explanation and Hindi medium students performed at par with English medium students.

9.1.1.2.2. Use of code-switching

This scaffold is first identified in RC2 when content was presented in Hindi only MoI. Students suggested using English for subject-specific terms. So, in next research cycle RC3 we used both MoI for vocal explanation by switching to English MoI from Hindi MoI and switching back to Hindi MoI. Content analysis of student's interviews shows the usefulness of this scaffold in RC3. We used this in RC4 to teach HHc group and found no significant difference between the post-test scores of HHc and EEc group.

9.1.1.2.3. Use of simple English MoI for on-screen text

We identified this scaffold in RC3 when students reported the shortcomings in use of Hindi MoI in on-screen text. The usefulness of this scaffold is confirmed for classroom environment in RC4 when Hindi medium students performed at par with English medium students while the written text was presented in English MoI and verbal explanation of the text was done in Hindi MoI.

9.1.1.2.4. Use of English for specialized and semi-specialized words

This scaffold was identified in RC2 when instructor used translation on subject-specific words and students and teachers listed it as a shortcoming. Teachers claimed that translating specialized vocabulary will never lead to increased English competency. We confirmed this finding in a qualitative analysis in RC3 when students reported that use of subject-specific words in English MoI will help them building subject-specific vocabulary. In the same study students reported shortcoming in use of transliteration of subject-specific vocabulary. In RC4 and RC5, when this scaffold was used, no significant difference was noted in post-test scores of HHc and EEc students and HHs and EEs students. In RC4 and RC5 we confirmed this scaffold to teach Hindi medium students in Hindi MoI. This will help students to develop specialized and semi-specialized vocabulary.

9.1.1.2.5. Explain specialized and semi-specialized vocabulary on first occurrence

We identified the need of this scaffold in RC2 when students asked questions related to specialized words. When we analyzed the transcript of the selected screencast (Table 5.14) we found that instructor used few specialized terms (execute, compile, parameter etc.) in screencast without explaining them and students were facing problems in comprehending the learning material. We used this scaffold in next prototype (RC3) and students did not ask any question related to the meaning of specialized or semi-specialized vocabulary.

Specialized word will be new if student is learning the subject for the first time. In that case explain it with the meaning, usage and examples. If the term is semi-specialized then explain it with the context of current subject using examples and usages. After giving special attention to specialized and semi-specialized terms on first occurrence these terms can be used in English on successive occurrence throughout the subject.

The vocal explanation of the specialized and semi-specialized terms will be in Hindi to teach in Hindi MoI.

Table 9.2 Language based scaffoldings useful to teach in bilingual MoI

No.	Detail of scaffolding	Where to use
1	Use of simple Hindi MoI for vocal explanation	Vocal explanation
2	Use of code-switching	Vocal explanation
3	Use of simple English MoI	On-screen text
4	Explain specialized and semi-specialized vocabulary on first occurrence	
5	Use of Specialized and semi-specialized words in English	On-screen text, Vocal explanation

9.1.1.3. Language based scaffolds rejected due to shortcomings

During the research work, we tried many language-based scaffolds. We selected only those screencasts that are found useful for the final solution. This section presents the scaffolds that are rejected because of shortcomings which are not found useful to teach vernacular medium students.

There are three scaffolds rejected, presented in Table 9.3. All of these scaffolds are related to the use of Hindi MoI. In RC3, we used Hindi for on-screen text with vocal explanation in Hindi MoI. Content analysis of student’s interviews showed the shortcomings in use of Hindi MoI for on-screen text. We used English MoI for on-screen text for RC4 and RC5 and Hindi medium student’s performance was equivalent to English medium students. Hence, we would recommend not to use Hindi MoI for on-screen text.

Translation and transliteration of specialized and semi-specialized words are rejected in RC2 and RC3 respectively. Students suggested that use of translation or transliteration will reduce their chance to enhance subject specific vocabulary. We used specialized words and semi-specialized words in English for on-screen text and vocal explanation in RC4 and RC5 and found them useful. Hence, we are not including this scaffold for the solution.

Table 9.3 Language based scaffoldings rejected in this thesis

S. No.	Details of scaffolding	Where to use
1	Use of Hindi MoI for on-screen text	On-screen text
2	Use of Translation of specialized and semi-specialized word	On-screen text, Vocal explanation
3	Use of transliteration of specialized and semi-specialized word	On-screen text, Vocal explanation

9.1.2. Cognitive scaffolds

Cognitive scaffolds are used to reduce intrinsic cognitive load or extrinsic cognitive load of vernacular medium students. Vernacular medium student faces high cognitive load when English MoI is used because he/she has to translate the presented material. The reason behind providing cognitive scaffold is to reduce the cognitive load of a student that he/she can use to translate the presented material. We conducted literature review and found that "visualization guidelines to teach educational content" and "multimedia principles" reduced the cognitive load of students.

9.1.2.1. Segmentation, Pre-training and visualization guidelines to teach educational content

Segmentation, pre-training and "visualization guidelines to teach various educational content" were identified in literature review conducted to solve the problems of RC2. In RC2, students reported several problems in understanding the presented content. To identify the problems, we conducted literature review on teaching content in 'need analysis phase' of RC3. We found that segmentation, pre-training and "visualization guidelines to teach educational content" not only helped in developing the content but also in reducing the cognitive load on students.

In RC3 we designed a prototype by following these principles and conducted a qualitative study. Content analysis of student's generated questions and interview transcript did not provide any shortcoming in the content. In RC4, we conducted a quantitative study on 105 students in classroom environment with the content designed by following these principles (except segmentation, as this could be provided only in student-controlled environment), we found that student's performance was satisfactory if the MoI of treatment was similar to student's MoI of K-12. But the performance of Hindi medium students receiving instructions in English MoI was significantly lower than the other two groups. Although the reason of poor performance was not clear we decided to use these principles for RC5, in screencast based self-paced environment.

In RC5, we conducted a quantitative study on 105 students in screencast based self-paced environment with the content designed by following these principles (including segmentation, as this could be provided in student-controlled environment), we found that student's performance was satisfactory for both English MoI and Hindi MoI. Hence, we accepted these scaffolds for the final solution to teach vernacular medium students.

Table 9.4 Details of cognitive scaffolds in final prototype

S. No.	Details of scaffolding	Type of cognitive load it reduce.
1	Segmentation and pre-training	Intrinsic
2	Create content using "visualization guidelines to teach educational content".	Intrinsic
3	Present content using "multimedia principles".	extrinsic

9.1.2.2. Multimedia principles to present educational content

This scaffold was identified in literature review conducted to solve the problems of RC2. In RC2, students reported several problems in the way content was presented in screencasts. To identify the problems, we conducted literature review on educational content presentation in 'need analysis phase' of RC3. We found that the multimedia principles not only help in content presentation but also reduce the cognitive load. The multimedia principles that were selected and used in our work are: split-attention effect, redundancy effect, verbal redundancy, synchronization and attention-cueing (Table 9.5).

In RC3, we designed a prototype by following the above mentioned principles and conducted a qualitative study. Content analysis of student's interview did not report any major shortcoming in the content presentation. In RC4, we conducted a quantitative study on 105 students in classroom environment with the content designed by following the same principles. We found that student's performance was satisfactory for both English MoI and Hindi MoI. Hence, we accept this scaffolding for final solution.

Table 9.5 Multimedia principles of educational content presentation to reduce cognitive load

No.	Multimedia principles to reduce cognitive load	Type of cognitive load it reduce.
1	Split-attention effect	Extrinsic
2	Redundancy effect	Extrinsic
3	Verbal redundancy	Extrinsic
4	Synchronization	Extrinsic
5	Attention cueing	Extrinsic

9.1.3. Affective scaffoldings

9.1.3.1. Self-paced learning environment

The self-paced learning environment removes various affective problems of students. This is identified in qualitative study presented in Section 2.2. In RC2 and RC3 we used self-paced study environment but we were unable to confirm the effect of this scaffold because of other problems in the treatment. In RC4 we did not use self-paced learning environment and found that HEc group performed poorly even when other language-based scaffoldings and cognitive scaffoldings were used to support vernacular medium students.

We again used self-paced learning environment in RC5 using screencasts. There was only one difference between the intervention of RC4 and RC5 and that was educational environment. In RC5 content was presented by same instructor with the same learning material of RC4 in a self-paced screencast based environment instead of classroom environment. HEs group or RC5 performed better than HEc group of RC4. The difference between the post-test scores of vernacular medium students in two different environments was significantly different and students did not report any shortcomings about the use of English MoI in screencasts.

This scaffold thus removes affective problems that are present in classroom environment. In classroom environment, vernacular medium students do not ask to repeat the instructions because of the fear of peers laughing at them. In self-paced screencast based learning environment, students learn in a student-centric environment where they can play, pause, repeat, and skim throughout the instructional content as per his/her pace.

Table 9.6 Scaffoldings used in different research cycles in this thesis

		Class room recorded videos (RC1)	Screencast (RC2)	Cognitively Scaffolded Screencast (RC3)	Face to Face classroom (RC4)	Cognitively Scaffolded Screencast (RC5)
Group ↓	Research methods →	Quantitative	Qualitative	qualitative	quantitative	quantitative
Language-based scaffolding ↓						
HH	Hindi MoI for vocal explanation					
	Translate specialized and semi-specialized words					
	Simple Hindi MoI for vocal explanation					
	Transliterate specialized and semi-specialized words for on-screen text					
	Hindi MoI for on-screen text					
	Code switching					
	Use English for Specialized and semi-specialized words for on-screen text and vocal explanation					
HH and HE	Use simple English MoI for on-screen text					
	Explain specialised and semi-specialised words on first occurrence					
HE	Simple English MoI for vocal explanation					
	Use of slow pace English MoI for vocal explanation					
Cognitive scaffolding ↓						
HH and HE	use of visualisation guidelines					
	use of multimedia principles for content presentation					

legend

accepted scaffolds — tested - no effect

rejected scaffolds — tested - found useful - accepted

tested - not useful - rejected

9.2.A scaffolding framework to teach vernacular medium students

We identified language-based scaffoldings and selected various cognitive scaffoldings and affective scaffoldings in our work (Section 9.1). A scaffolding framework to teach vernacular medium students consists the following types of scaffoldings: 1) language-based scaffoldings, 2) scaffoldings to reduce intrinsic cognitive load, and 3) scaffoldings to reduce extrinsic cognitive load.

There are two ways to teach a vernacular medium student in English MoI 1) use English only MoI, 2) use Bilingual MoI. English only MoI consists on-screen text and vocal explanation in English.

We are using the term "Bilingual MoI" to represent a mix of primary and secondary languages for MoI. In our framework presented in Table 9.7, we considered both possibilities to teach a vernacular medium student. Hence our framework can be divided into two parts based on English only MoI, and Bilingual MoI. Scaffolding to reduce intrinsic and extrinsic cognitive load are same for both parts. The difference is only in language based scaffolding between both parts of framework. Details of intrinsic and extrinsic scaffoldings are given in Section 2.5.6. In this chapter we will discuss only language based scaffoldings. Based on our findings, we identify and test these scaffoldings in five research cycles during our research work. These research cycles are presented from chapter 4 to chapter 8 and scaffolds identified in these research cycles are presented in Section 9.1 and Table 9.6.

There are several requirements to be fulfilled before applying the scaffolding framework presented in this section. These requirements are discussed in Section 9.2.1. Framework to teach vernacular medium students in English only MoI is presented in Section 9.2.2 and Framework to teach vernacular medium students in Bilingual MoI is presented in Section 9.2.3.

Table 9.7 Framework to teach vernacular medium students in English MoI

	English only MoI ↓	Bilingual MoI ↓
	Language Based Scaffolds	
	Use of simple English MoI for on-screen text	
	Explain specialized and semi-specialized words on first occurrence	
	Use of simple English MoI for vocal explanation	Use of Simple Hindi MoI for vocal explanation
	Use of slow pace English MoI for vocal explanation	Use of code-switching
		Use of English MoI for specialized and semi-specialized words for on-screen text and vocal explanation.
	Cognitive Scaffolds ↓	
	Use of Multimedia Principles (Section 2.5.6.2)	
	Use of visualization guidelines for corresponding content type (Section 2.5.6.1)	
screencast based self-paced learning →	Recommended	Can be used
face-to-face classroom→	Not Recommended	Recommended

9.2.1. Requirements of the framework

It is required to carefully design the curriculum before teaching any subject. Designing a curriculum involves writing learning objectives of the subject at chapter and topic level, carefully dividing the content into chapters and topics and deciding pre-requisites for each topics. This will help in identifying the correct sequence in which learning material needs to be presented. This is important as incorrect sequence of the content leads to instructional gap that may increase the cognitive load on a student.

This requirement was identified in RC1 when students did not learn from videos even when they were presented in their primary language. The need for use of instructional design principles is seen again in RC2 where teachers and students both reported the problem in educational content. Instructional design principles make the acquisition of knowledge and skill more efficient, effective, and appealing (Merrill, Drake, Lacy, Pratt, & Group, 1996).

We followed a standard curricula developed by ACM CS committee in our work. An instructor can follow a standard curricula of the subject or follow instructional design principles to design a curriculum himself. Instructional design principles help in writing learning objectives, deciding prerequisites and appropriate chunking and sequencing of learning material.

9.2.2. Framework of scaffolding to teach vernacular medium students in English only MoI

Framework to teach vernacular medium students in English only MoI is shown in Table 9.8. With the help of this framework cognitive, language-based and affective scaffoldings are provided to vernacular medium students that will help in comprehending English only MoI. Details of language-based scaffoldings are given in this section.

Table 9.8 Scaffolding framework to teach vernacular medium students in English only MoI

English only MoI
Language Based Scaffolds
Use of simple English MoI for on-screen text and vocal explanation
Explain specialized and semi-specialized words on first occurrence
Use of slow pace English MoI for vocal explanation
Cognitive scaffolds
Use of Multimedia principles (Section 2.5.6.1)
Use Visualization Guidelines for corresponding content type (Section 2.5.6.2)
Use of screencast based self-paced learning environment

9.2.2.1. Use of simple English MoI

English is a secondary language for vernacular medium students. Vernacular medium students study English Grammar and English literature in K-12 in an ESL program. Their English vocabulary is weak as compared to that of English medium students. They remain unable to comprehend the meaning of a sentence if it contains words which are unknown to them. Use of simple English words in a sentence will make it easy for them to comprehend it. Use of simple English MoI means to use those words in instructions which are already known to the students. We achieved this by replacing complex English words with their simple synonyms. This scaffold can be used for on-screen text as well as for vocal explanation.

Sometimes it is difficult for a teacher to identify complex words. It is advisable to ask some vernacular medium students to mark the complex words. We took help of ten vernacular medium students to mark the complex words during the design of learning material. Figure 9.1 shows a sample of video script taken from a standard book on C programming (Kanetkar, 2008). All coloured words are marked by students as unknown to them. The number above the words shows how many students marked these words as unknown. Red coloured words are general English words, blue coloured words represents specialized words and green coloured words are semi-specialized words.

> As we saw earlier[4], an entity[8] that may vary[10] during[3] program execution[7] is called a variable[4]. Variable names are names given to locations in memory. These locations can contain integer[9], real[2] or character[1] constants[3]. In any language, the types of variables that it can support depend on the types of constants that it can handle[2]. This is because a particular[10] type of variable can hold[8] only the same type of constant. For example, an integer variablecan hold only an integer constant, a real variable can hold only a real constant and a character variable can hold only a character constant.

Figure 9.1 A sample of video script, showing complex words

Some sentences have more than one difficult word (Figure 9.1) that makes it complex to comprehend. We used this scaffold for complex general English words (red coloured words) and replaced them with their simple synonyms. We did not change the word if we did not find a simple synonym of that word. We also removed “as we saw earlier” phrase from the text as it did not aid learning. Figure 9.2 shows the simple synonyms of complex general English words we used to scaffold learners.

~~As we saw earlier (early)~~, an entity (thing) that may vary (change) during (during) program execution is called a variable. Variable names are names given to locations in memory. These locations can contain integer, real or character constants. In any language, the types of variables that it can support depend on the types of constants that it can handle (support). This is because a particular (special) type of variable can hold (keep) only the same type of constant. For example, an integer variablecan hold (keep) only aninteger constant, a real variablecan hold (keep) only a real constantand a character variablecan hold (keep) only a character constant.

Figure 9.2 Replace complex general English words with simple synonyms

9.2.2.2. Explain specialized and semi-specialized words on first occurrence

Previous scaffolding is helpful to handle general English words. The scaffolding discussed in this section is used to handle specialized and semi-specialized words. Specialized vocabulary is one which is related to the subject and not used in general communication. Semi-specialized vocabulary is one that is used in general communication and has altogether a different meaning for the subject. In Figure 9.2, blue coloured words show specialized words and green coloured words are semi-specialized words. These words are execution, variable, integer, real, character and constants. These terms are new to the students and they represent the concepts. We explained these terms by following "visualization guidelines to teach concept" (Section 2.5.6.1.2) on their first occurrence. Figure 9.3 shows the script prepared to teach "variable" concept in the context of computer programming. This text is used for vocal explanation along with the slide presentation. Cognitive scaffoldings to reduce extrinsic cognitive load are used with the explanation. The activities of computer screen are recorded with the vocal explanation to create a screencast.

The explanation of specialized words with visualization guidelines to teach concept help in building mental model of the term and students develop the subject specific vocabulary.

Variable

- Definition: A thing that may vary during program execution is called a variable.
- Example:
    - A variable 'price' (representing the price of a product in a program) will change over the period of time.
    - A variable 'discount' will change to increase or decrease the discount on a product.
    - A variable 'obtained_marks' will change to store the obtained marks of a students in an exam.
- Analogy:
    - If you want to store age of each person from your family. You need a variable to store age as age of each person will be different. You can name this variable 'age'. The value of 'age' variable will change according to the member of the family.

Figure 9.3 Script prepared to teach variable concept

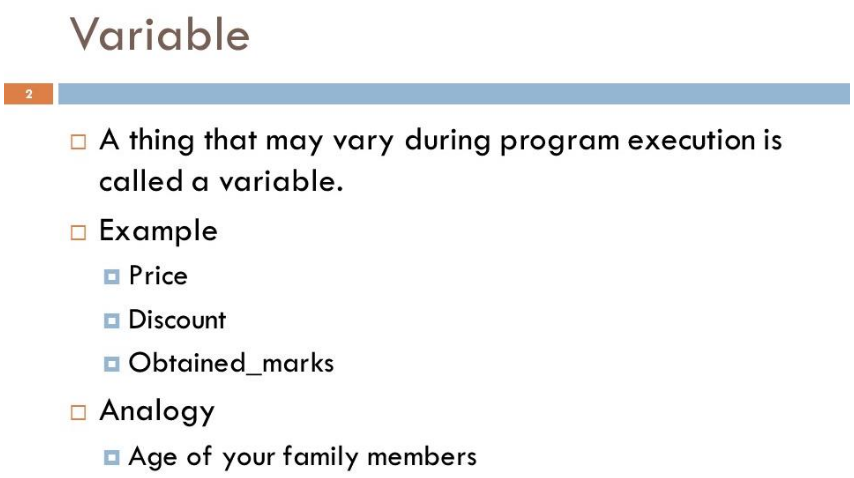


Figure 9.4 Slide creation to teach variable concept

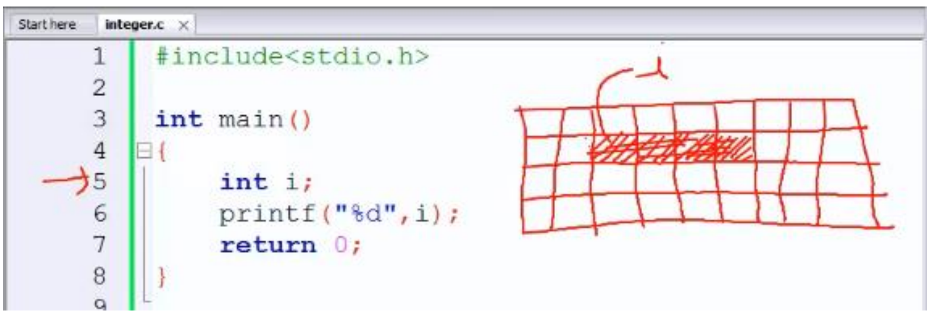


Figure 9.5 Explanation of variable using visualization guidelines and multimedia principles

9.2.2.3. Use of slow pace English MoI for vocal explanation

This scaffolding can be used for vocal explanation only. Vernacular medium students are new to English MoI. Their English listening skills are also low. To comprehend vocal explanation delivered in English MoI students need to listen and translate it. This increase the cognitive load on the student. Use of slow pace for vocal explanation provides extra time to listen and translate the instructions before working memory is overloaded with many unknown words. The script to teach variable concept is presented in Figure 9.3. This script is converted to slide (Figure 9.4) that will appear as on-screen text line-by-line. Each line will be explained in slow pace by reading the script (Figure 9.4). The screencast will be recorded with slow pace vocal explanation by following visualization guidelines (Section 2.5.6.1) and multimedia principles (Section 2.5.6.2). One screenshot from the screencast is shown in Figure 9.5 that shows the use of visuals and attention-cueing to explain the concept of variable to a vernacular medium student.

9.2.2.4. Screencast based self-paced learning environment

Screencast based self-paced learning environment is necessary if English only MoI is used to teach vernacular medium students. Screencast based self-paced learning environment provides technical and incidental scaffolding that support students to comprehend the learning material presented in English only MoI. It also eliminates affective problems that are available in classroom environment. Benefits of screencast based self-paced learning environment are listed in Section 2.5.3.3. These benefits are summarized below:

1. Video player control allows a student to jump anywhere into video, learner can go back, forward in the timeline. This gives the opportunity to learners to re-watch the section if he/she did not comprehend it on the first attempt.

2. Use of screencast reduces the distance from teacher and whiteboard that is reported as one of the distractions in classroom environment.

3. Students do not make notes while learning from screencast if they know that screencast will be provided to them.

9.2.3. Framework of scaffolding to teach vernacular medium students in Bilingual MoI

Framework to teach vernacular medium students in English only MoI is shown in Table 9.9. With the help of this framework cognitive and language-based scaffoldings are provided to vernacular medium students that will help in comprehending English only MoI. Details of language-based scaffoldings are discussed in this section.

Table 9.9 Scaffolding framework to teach vernacular medium students in Bilingual MoI

Bilingual MoI
Language Based Scaffolds
Use of simple English MoI for on-screen text
Explain specialized and semi-specialized words on first occurrence
Use of Simple Hindi MoI for vocal explanation
Use of code-switching
Use of English MoI for specialized and semi-specialized words for on-screen text and vocal explanation.
Cognitive Scaffolds
Use of Multimedia Principles (Section 2.5.6.2)
Use of Visualization Guidelines for corresponding content type (Section 2.5.6.1)
Screencast based self-paced learning OR face-to-face classroom environment

9.2.3.1. Use of simple Hindi MoI for vocal explanation

Use of vocal explanation in Hindi MoI can be difficult to understand for students if complex Hindi words are used. Rarely used Hindi words are known as complex Hindi words and students are unaware of these words even if students are from Hindi medium. For example, we used "विद्यार्थी को मिलने वाले नंबर" rather than "प्राप्तांक" in the script (Figure 9.6). Use of complex words for vocal explanation will make it difficult to comprehend the learning material.

9.2.3.2. Use of code-switching

Code-switching is a term used to switch vocal explanation between primary language and secondary language according to the need of the learner. The scaffold "use of English for specialized and semi-specialized words for vocal explanation" creates the necessity to use code-switching. Use of code-switching allows a student to listen to the pronunciation of subject-specific words. This may help in developing listening skills for subject-specific words. The primary objective to use code-switching is not to use translation of these terms as translation will develop primary language competency but our goal is to develop English competency for vernacular medium students. Figure 9.6 presents the script with code-switching to teach concept of variable in bilingual MoI. Here use of English words for variable, program, program execution may help learners to build subject-specific vocabulary. Otherwise these words would be चर-राशि, प्रोग्राम and निष्पादित, teaching with these words will not develop subject-specific vocabulary of students.

Variable

- परिभाषा: वह चीज जो program execution के समय बदल सकती है, variable कहलाती है।
- उदाहरण:
  - variable ‘price’ (जो किसी program में किसी वस्तु के मूल्य को बताता है) समय के साथ बदल सकता है।
  - variable ‘discount’ किसी वस्तु पर मिलने बाली छूट के साथ बदल सकता है।
  - variable ‘obtained_marks’ प्रत्येक विद्यार्थी को मिलने वाले नंबर के साथ बदलेगा।
- Analogy:
  - यदि आप किसी program में अपने परिवार के सभी सदस्यों की उम्र को सहेजना चाहते हैं परिवार के सभी सदस्यों की उम्र अलग-अलग होती है, आप एक नया variable बना सकते हैं जिसको आप नाम दे सकते हैं 'age’. ‘age’ variable का मान परिवार के लोगों की उम्र के साथ बदलेगा।

Figure 9.6 Script to teach variable in bilingual MoI with code-switching

9.2.3.3. Use of simple English MoI for on-screen text

In bilingual MoI we will use the code-switching for vocal explanation by switching from primary language MoI to secondary language MoI, as shown in Figure 9.6. This scaffold makes it necessary to use simple English MoI for on-screen text even if the MoI for vocal explanation is Hindi because this will allow vernacular medium students to read English from on-screen. Use of simple English words in a sentence will make it easy for them to comprehend it. Use of simple English MoI means to use those words in instructions which are already known to the students. On-screen text in English screencast will be similar to the on-screen text in bilingual MoI. The slide to teach “variable” concept is similar for both English MoI and Bilingual MoI, presented in Figure 9.4. As first line will appear on-screen teacher will read it in English and then explain it with the help of script presented in Figure 9.6.

9.2.3.4. Use of English for specialized and semi-specialized words

Using चर-राशि for variable or निष्पादन for execution will not help vernacular medium students to develop subject-specific vocabulary that will impact their performance in post-test. This scaffold is necessary to develop subject specific vocabulary in vernacular medium students.

9.3.How are limitations of practical context addressed?

We identified four limitations of practical context from the experience of teachers and students. These limitations are limited time, English major classrooms, non-availability of learning material in local-language and exams in English. We try to address these limitations in our final intervention. This section presents how our final intervention addresses these limitations.

9.3.1.1. Limited time

An engineering student learns in a very busy schedule and hence there is no time to provide scaffold outside the classroom. For this reason we try to provide the scaffold in the classroom environment itself either with the help of screencasts or face-to-face learning. Scaffolding framework addresses this limitation by utilizing the classroom time to scaffold learners. Screencasts developed with the scaffolds, detailed in Section 9.1, will scaffold student in the classroom environment. This will help teachers and students to utilize the classroom time and there will be no need to take or attend extra class to re-teach the content. This can be easily operationalized using smart phones available at low cost.

9.3.1.2. English-major classroom

A classroom where the number of vernacular medium students is less than that of English medium students is known as English-major classroom. This environment creates some affective problems for vernacular medium students. Students hesitate to ask questions in the classroom, do not actively participate in the discussion due to fear of being laughed at by peers at their low English competency. The self-paced screencast based environment leaves no room to ask question at the time of learning the material. Vernacular medium students face little or no difficulty to understand the discussion as now they have learned the content that was presented in English and they know the meaning of most of the subject specific terms required to understand the discussion. Presenting the material using screencast and discussing on the questions generated during watching the screencast narrows down the context of discussion, this will also help vernacular medium students.

9.3.1.3. Non-availability of learning material in local-language

In order to understand the subject, students prefer self-study with the textbooks or material available online. Unfortunately most of the subject specific material is not available in local languages. We interviewed students to know how they learn at home. We found that students used English to Hindi dictionary in the beginning of the course but later found that the subject specific terms are not available in Hindi dictionary and hence switched to English to English dictionary. Based on the findings from experiments and literature review we developed three scaffolds that addressed this issue:

- Use of simple English MoI for on-screen text and vocal explanation
- Use of slow pace for vocal explanation
- Explain the specialized and semi-specialized words on their first occurrence

These three scaffolds in a screencast make it suitable for vernacular medium students and they no longer need to learn the content in primary language. The screencast will be available to them even after the class and they can self-study with the screencast itself.

9.3.1.4. Exams in English

During the study in classroom or self-study at home vernacular medium students either face difficulty in gaining knowledge about the subject or in improving the competency in English that is required to write the examination. In the solution we are providing English only content with cognitive and language based scaffold. While studying in classroom or at home, student will learn from the English medium instructions that involve reading and listening English only instructions. This will help student to gain competency in English reading and English listening. The way we address different English language terms helps student to learn using specialized and semi-specialized words. This will improve learners' confidence in reading the exam paper written in English and answering it using general, specialized and semi-specialized vocabulary.

9.4. Summary

This chapter presents the framework to provide scaffolds to teach vernacular medium students. Teachers can use this framework to create learning material for vernacular medium students. Chapter 10 discusses overall thesis implementation leading to conclusion and future scope or research work.

Chapter 10

Discussion

This concluding chapter of the thesis begins with an overview of the problem of vernacular medium students addressed, and the solution implemented (Section 10.1). Each research question posed and answered in Chapters 4 through 8 is examined and discussed (Section 10.2). Claims are made based on the results obtained from the qualitative and/or quantitative studies presented in this thesis. The generalizability of the claims is explored and an attempt is made to argue that the boundaries of the solution can be extended to other languages and topics (Section 10.3). This is followed by limitations of the thesis (Section 10.4), and the contributions of the thesis for research as well as practice (Section 10.4). The chapter concludes with possible directions of future work (Section 10.6).

10.1. Overview of problem and solution

Vernacular medium students need to develop English competency along with the subject competency as English competency is important to remain updated with current knowledge, work in engineering domain specific environment and increase the social context of choice. Students who come from other than English medium background find it difficult to study in English MoI classroom, read from English textbooks and write examinations in English. They also face affective problems because of the treatment given to them by teachers and peers. They remain unsuccessful to understand from textbooks because of their limited English vocabulary and non-availability of specialized and semi-specialized vocabulary. Teachers cannot keep on continuing to teach them in their primary language as this will stop building their competency in English and they will face difficulty in examination. If teachers continue to teach them in English, vernacular medium students will not be able to gain subject specific knowledge. How to teach vernacular medium students to increase their subject knowledge with English language competency within the limitation of practical context is the teaching-learning problem addressed in our work.

To solve this problem, initially we identified the problems of vernacular medium students through literature review (Section 2.1) and qualitative analysis (Section 2.2). We found that vernacular medium students face high cognitive load because of English MoI. This cognitive load can be reduced with the combination of cognitive scaffolds and language based scaffolds. Cognitive scaffolds are provided to reduce intrinsic and extrinsic cognitive load. Scaffolds to reduce intrinsic cognitive load depends on the way educational content is developed. Scaffolds to reduce extrinsic cognitive load are based on multimedia principles. Our experiments show that the self-paced learning environment is more suitable for vernacular medium students compared to classroom environment. Based on these findings we try to provide this thesis provides a technology based solution to teach vernacular medium students by creating a scaffolding framework.

10.2. Answering research questions

In this research, the main research issue related to the teaching-learning of vernacular medium students was addressed. The main RQ was: "***How to scaffold a vernacular medium student within the limitations of practical context to achieve the goals of bilingual education?"*** This research question is answered using EDR (Education Design Research) method which is recommended for addressing complex problems of education. EDR followed in our work contains four phases namely 1) need analysis, 2) design and develop prototype, 3) evaluation and 4) problem resolution (see Figure 3.2).

The first step towards addressing the RQ was to identify the problems of vernacular medium students. The problems of vernacular medium students were identified by literature review and content analysis of interview of vernacular medium students (Section 2.2). We found that poor English competency acts as a barrier to gain subject specific knowledge. Also, learning in an English major class, where number of students from English medium is higher than that of vernacular medium student, leads to several affective problems including decrease in self-confidence and loss of motivation. In a self-paced study environment, vernacular medium students find it difficult to infer the meaning from the sentences written in textbooks. There are mainly three reasons behind this-

- The students are unable to understand the meaning of specialized or semi-specialized words written in English even if the subject is known to them as they have read these terms in their local language throughout the K-12 education.
- These students do not understand the meaning of some general English terms as they have used limited vocabulary in K-12.
- Non-availability of specialized and semi-specialized vocabulary.

The task of a vernacular medium student becomes threefold in receiving educational content in English MoI. They have to make sense of the instructional tasks, attain linguistic competence and master the content. Because of this increased cognitive load, vernacular medium students are unable to match their pace with the teacher in face-to-face environment when content is delivered in English MoI.

Based on these findings we assumed that vernacular medium students will not face difficulty in learning computer programming in Hindi MoI and their performance would be similar to that of English medium students learning computer programming in English MoI. We also assumed that vernacular medium students learning computer programming in English MoI would perform lower than those vernacular medium students who are learning programming in Hindi MoI. To confirm our assumptions and to identify the problems of vernacular medium students in learning programming in English MoI, we developed following research questions for first research cycle.

RQ1.1: Do undergraduate Hindi medium students learning introductory programming by watching video lectures in Hindi, perform better than similar students who watch the same lectures in English?

RQ1.2: Does self-reported prior knowledge play a role in the performance of students?

These research questions are answered in a quantitative research study presented in Chapter 4. We used classroom recorded video in a classroom environment. We found that impact of MoI cannot be measured with classroom recorded videos as no group performed well. We concluded that classroom videos are not effective for video-based learning. We also found that classroom environment is not the suitable environment to use video based teaching. Hence we repeated the experiment for educational screencasts to measure the effectiveness of educational screencast recorded in Hindi MoI and English MoI in the second research cycle. This is operationalized into the following specific questions:

RQ2.1: What is the expected and actual effectiveness of educational screencasts recorded in English MoI to teach programming to vernacular medium students?

RQ2.2: What is the expected and actual effectiveness of educational screencasts recorded in Hindi MoI to teach programming to vernacular medium students?

In the second research cycle, we selected screencasts that are developed especially for video-based learning and conducted a qualitative study with ten students and three teachers. The teachers were interviewed and their review of the videos was collected on a paper. Content analysis was performed on the data generated by teachers to measure the expected effectiveness of the screencasts. We divided the ten students into two equal groups named HH and HE. HH group was watching Hindi screencasts and HE group was watching English screencasts. Students were asked to write question on a notepad, if they had any, and a teacher would answer all the questions after the treatment. Students' interviews were conducted after they finished watching screencasts. Content analysis was performed on the data generated by students to measure the actual effectiveness of the screencast.

We found that these videos needed improvement in the systematic design of educational content and presentation style. Also, these videos needed improvement in handling vocabulary to teach vernacular medium students. For third research cycle, we conducted literature review on reducing cognitive load with the help of content development and presentation. We also conducted literature review on using specialized (subject-specific) vocabulary for vernacular medium students. We then created five screencasts based on the findings of previous research cycle and literature review. To measure the effectiveness of the videos we did a qualitative study in third research cycle. The qualitative study is operationalised with the following research questions.

RQ3.1: What is the actual effectiveness of using transliteration of subject-specific terms in Hindi MoI screencasts to teach computer programming to vernacular medium students?

RQ3.2: What is the actual effectiveness of Hindi MoI screencasts, planned using instructional design principles, to computer programming to teach vernacular medium students?

RQ3.3: What is the actual effectiveness of Hindi MoI screencasts, created using visualization guidelines of educational content types, to teach computer programming to vernacular medium students?

RQ3.4: What is the actual effectiveness of Hindi MoI screencasts, created using multimedia principles, to teach computer programming to vernacular medium students?

RQ3.5: What is the actual effectiveness of educational screencasts recorded in Hindi MoI to teach vernacular medium students?

Qualitative research in this research cycle is carried out with students to measure the actual effectiveness of the prototype. Students were allowed to watch screencasts at their pace and write questions on a notebook during the treatment. We conducted interviews of students after they finished watching videos. Content analysis was performed on the data generated by students to measure actual effectiveness of the screencasts. We did not find any shortcoming in teaching method of educational content and its presentation. Few shortcomings were identified in the use of language and screencasts needed improvement at the language level.

Fourth research cycle presents a quantitative study, where we implemented all findings of previous research cycles and interventions were provided in a classroom environment. The research questions of fourth research cycle are given below.

RQ4.1: Do undergraduate Hindi medium students learning introductory programming in classroom in Hindi perform better than similar students who learn programming in classroom in English?

In order to determine which content types should be taught in Hindi and which content types could be taught in English, we had the additional question:

RQ4.2: What is the effect of MoI for varying content types in programming instruction provided in general classroom setting?

The learning material for fourth research cycle was created by following instructional design principles and visualization guidelines to teach educational content types (Section 2.5.6.1). The content was presented by following multimedia principles to reduce cognitive load. We found some problems in the classroom environment because of which it is not suitable to teach vernacular medium students. We created next prototype after solving this problem for next research cycle.

In fifth research cycle, we used video based self-paced study environment in a quantitative study. The content development and presentation was based on multimedia and instructions design principles to provide cognitive scaffolds. Language based scaffoldings were designed by bilingual theory and findings of all previous research cycles. Research questions for this research cycle are discussed here.

We created following specific question to measure the impact of the MoI on the programming abilities of primary language learners.

RQ5.1: Do undergraduate Hindi medium students learning introductory programming by watching screencasts in Hindi, perform better than similar students who watch the same screencast in English?

In order to determine which content types should be taught in Hindi and which content types could be taught in English using screencast, we had the additional question:

RQ5.2: What is the effect of MoI for varying content types in screencast based programming instruction?

We created one question to determine how change in learning environment affected the performance of students.

RQ5.3 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?

One more question was created to measure the effect of medium of instruction on the performance of primary language students, for both classroom and screencast.

RQ5.4: 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?

We found that vernacular medium students performed significantly better in self-paced video based environment compared to classroom environment when taught in English MoI. The performance of vernacular medium students in fifth research cycle was satisfactory and it was completing the goals of bilingual education within the limitations of practical context. Hence, we decided to conclude our research work.

10.3. Generalizability of the Solutions

Our experiments were limited in terms of language, subject and learning environment. Hence, we believe that the generalizability of our work can be explained in these three area.

Language: Our experiments were based on Hindi (primary language) and English (secondary language). These experiments were conducted on the students who studied English in K-12 as a subject. Reading a language as a subject helps a learner to gain competency in reading, writing, listening and grammar. Although this competency is very low still can help student to comprehend learning material presented in English only MoI if scaffolding framework mentioned in Chapter 9 is used. Hence, we believe that the guidelines will work for any two languages as far as the secondary language is taught to learner as a compulsory subject in K-12.

Subject: We have conducted experiments with programming in computer science. Computer programming is new to most of the Hindi medium students as this is not taught at K-12 level. We expect that this solution will work with most of the computer science subjects. Although we feel that before making any claim about the subject more experiments are required.

Program: Universities use English MoI for professional courses. Engineering is one of such course. English is used for vocal explanation in the classroom, internal and external examination and other official works. Knowledge of English is the necessity of students who enrol in the program. So, they understand the importance of English and try to increase their competency in it. We tested the usefulness of the content, created with the scaffolding framework, on these students. They made their serious effort to learn from the content that was presented in English because being a student of a professional program they understand its importance and want to increase their competency in it. We believe that students studying in any other professional course like medical, law, etc. will also try to learn from a CLIL environment. The framework might be useful for these students as well.

On the other hand, students studying in a graduation course where English is not a compulsion would not put sincere efforts to learn from the content presented in English. In that case, the scaffolding framework to teach vernacular medium students might not work.

10.4. Contribution of the thesis

The major contribution of this thesis is to develop a framework to teach programming to vernacular medium students in English only MoI or bilingual MoI. Major components of this framework are the language based scaffolds, cognitive scaffolds and appropriate learning environment. These contributions are listed below:

- The thesis provided a rich qualitative description of the problems of vernacular medium learners facing university-level CS classes. The scaffolding framework is a significant contribution, but the thesis also helps others to understand the problem well, with a rich collection of quotes and stories.

- The thesis also provided a process for implementing the framework, as we mentioned in Chapter 9. Each point of the framework is supported with data, but is also described in detail with examples. The thesis works as a contribution to the research community, and as a guide to instructional designers who wish to implement the framework.

- Language based scaffolds are identified, implemented and tested to teach vernacular medium students in a secondary language.

- Visualization guidelines to teach various educational content are selected, implemented and tested to reduce the intrinsic cognitive load of vernacular medium students.

- Multimedia principles are selected, implemented and tested that help in reducing the extrinsic cognitive load of vernacular medium students.

- Appropriate teaching-learning environment is identified and tested in which cognitive, and language based scaffolds are effective for a vernacular medium students.

- Based on these findings we created and tested scaffolding framework to teach vernacular medium students. This scaffolding framework can be used by researchers and educators to develop educational screencasts to teach programming languages in a CLIL program.

During the development of the prototype, we developed learning material like slides, source code, and screencasts. These learning materials are tested to teach Hindi medium students in English MoI. Teachers or researchers can use this material to teach vernacular medium students or to create new learning material. These can be considered as minor contribution of this thesis:

- Screencasts in English as well as in Hindi are developed to teach C programming language that covers major topics of programming language. Running time of videos was 3 hours 10 minutes in one language and thus a total of 6 hours 20 minutes training screencasts were recorded.

- Sixteen source codes were written in C programming language. Slides were created and validated by following multimedia principles and ACM CS curricula.

- All learning resources created for research and mentioned in this thesis are available online[6] under creative commons license.

10.5. Limitations

While this thesis has produced encouraging findings and useful contributions, its limitations need to be identified and analysed.

First limitation of the framework, presented in our work, is based on the sample of vernacular medium students. We selected only those students who have studied in ESL environment during K-12. In ESL environment English is taught as a second language and other subjects are taught in primary language. ESL environment helps students to develop English vocabulary, grammar, writing

[6] http://www.et.iitb.ac.in/sfvms

skills and listening skills. Although ESL environment develop low proficiency in English, this low proficiency helps them to understand English MoI with the language-based scaffolds and cognitive scaffolds discussed in this thesis. The language based scaffolds used in the framework can be provided to those students who have basic knowledge of English. Hence, this framework may not work on the students who have studied only in one language during K-12 and have no knowledge of English.

Second limitation is related to the nature of the subject we chose for the experiment. Computer programming is a new subject for most of the undergraduates. Students are unaware of subject-specific vocabulary related to a new subject because they are studying it for the first time. Being the new subject, there is no prerequisite for computer programming hence syllabus is designed without any prerequisite keeping a novice learner in mind. But the syllabus of the subjects students have studied in K-12 (i.e. physics, chemistry or mathematics) is decided with a long list of prerequisites. In such subjects list of subject-specific words may be very long and making mental model for each word might not be possible for the teachers. One possible solution for this problem is to provide subject-specific dictionary in English-primary language and ask them to memorise it. Remembering a long list of words and utilizing them while receiving English MoI will increase the cognitive load on student that will result in low performance. Hence more scaffolds are required to identify and test that helped learner to link primary language meaning of the specialized word presented in English MoI to comprehend the learning material.

Third limitation is related to the methodology. Based on the nature of the post-test we used to measure the extent of learning of the students, we could not claim that students' programming ability has improved but we could say that significant improvement in students' post-test scores was visible when they were taught with the content designed by following the scaffolding framework.

10.6. Future work

Expansion of scaffolding framework to teach more subjects

Subjects like mathematics, physics and chemistry are not new to vernacular medium students in an undergraduate program. Students are familiar with the vocabulary of such subjects in primary language. In order to understand such subjects in English MoI at undergraduate level, a student needs to remember a long list of specialized terms in English. Use of the scaffolding framework presented might be impractical for the instructors of these subjects because making a mental model of each specialized word is a time-consuming process. This creates the requirement of different scaffolds when English only MoI is used. An interested researcher can identify new scaffolds and test them for these subjects.

Expansion of scaffolding framework to improve the performance

We tested this framework to teach vernacular medium students in English only MoI and bilingual MoI. Significant difference was found between the post-test scores of vernacular medium students in these two MoI. Students studying in bilingual MoI performed better than those studying in English MoI. Although the performance of vernacular medium students taught in English MoI was satisfactory and significantly better when these students were taught without scaffolds. A future work can be to identify and test more scaffolds to minimize the difference between the performances of these two groups.

Technology based solution for teachers

The framework presented in this thesis demands lots of work from an instructor. Technology based solutions can be created to minimize the task of the instructor. For example, a platform can be created that accesses corpus of English and Hindi words and suggests simple synonyms for complex words based on the frequency of the words used in K-12 textbooks. This will make it easier for a teacher to identify the complex words and select appropriate synonyms.

Test the scaffolding framework to teach in various environments

In our work we tested the effectiveness of the framework in a controlled environment where students have no choice other than watching the screencasts for the given time. Screencasts are being used in various platforms like MOOC and flipped classroom. These platforms create a learning environment where students are free to watch screencast according to their choice. A need to test this framework for these instruction delivery platforms also can be a future work. This testing might result in new scaffolds.

Test the scaffolding framework for other languages

In this thesis we tested the framework on two languages Hindi as primary MoI and English as secondary MoI. An immediate future work can be to test this framework for other primary languages like Kannada, Bengali, Gujarati, Marathi, Punjabi and other Indian and foreign languages.

This list of possible directions of future work is merely indicative and not exhaustive. The above directions can be considered to be a starting point in the rich field of identifying and testing more scaffolds for scaffolding framework.

Appendix I: Post-test for RC1

1. In the statement int i = 'a'; what will store for value of variable i?
a) ASCII value of character 'a' [ ]
b) 'a' itself [ ]
c) nothing program will give error [ ]
d) none of them [ ]

2. In the statement int i = 'a'; How many bytes will be reserved for variable 'I' in computer memory?
a) 1 bytes [ ] b) 4 bytes [ ]
c) 2 bytes [ ] d) no memory will reserve [ ]

3. In a program we want to calculate percentage of a student up to two decimal points. Variable name that will store the value of percentage named percentage. What data type is appropriate for 'percentage'?
a) int [ ] b) float [ ] c) char [ ]

4. Identify initialization statement(s) in the following program
1. int main()
2. {
3. int i;
4. int j;
5. i = 5;
6. j = I;
7.}
a) 3 & 4 [ ] b) 5 & 6 [ ]
c) 3,4 & 6 [ ] d) only 5 [ ]

5. Identify declaration statement(s) in the program written in question 4.
a) 3 & 4 [ ] b) 5 & 6 [ ]
c) 3,4 & 6 [ ] d) only 5 [ ]

6.) From the context of computer program find out the value of variable 'i'.
int i = 20 + 6 / 4;
a) 21.5 [ ]
b) 21 [ ]
c) 6.5 [ ]
d) none of them [ ]

7. Write following equation into corresponding C++ statement.

$$x = \frac{-b + (b * b) + 2 * 4ac}{2a}$$

…………………………………………………
…………………………………………………

8. A character variable can at a time store
a) 8 characters [ ] b) 1 character [ ]
c) 256 characters [ ] d) none of them [ ]

9. The statement char ch='z' would store in ch
a) The character 'z' [ ]
b) ASCII value of Z [ ]
c) Z with inverted commas [ ]
d) both a) and b) [ ]

10. Which of the following is not a character constant
a) 'Thank You' [ ] b) 'Enter P, N, R' [ ]
c) 23.56E-03 [ ] d) all of the above [ ]

11. Which of the following is odd one out
a.) area = 3.14 * r ** 2; [ ]
b) volume = 3.14 * r ^ 2 * h; [ ]
c) int 3 * 150; [ ]
d) exp = exp * 2; [ ]

12. Which of them is allowed in C++ arithmetic instruction –
a) [ ] [ ] b) { } [ ]
c) ( ) [ ] d) all of them [ ]

13. The expression x = 4 + 2 % 8 evaluates to
a) 6 [ ] b) 4 [ ]
c) 0 [ ] d) none of them [ ]

14. Which of the following are invalid variable names?
a) #Salary [ ] b) Salary [ ]
c) My_Salary [ ] d) MySalary [ ]
e) Salary. [ ] f) My-Salary [ ]
g) 2MySalary [ ] h) my_salary [ ]
i) main [ ]

15. Which of the following statements is wrong
a) pi = 3.14 [ ]
b) con = 'A' * 'E' * 'C'; [ ]
c) this = 'T' * 20; [ ]
d) 3 + a = d; [ ]

Appendix II: Slides prepared in RC4 and RC5

DAY 1

Machine Needs Instructions

Paddle, break, handle

Kick, self, rotate, accelerator, clutch, gear

Switch on / off

Programming

Program

- Using programming language we create instructions or **set of instructions.**
- This set of instructions is also known as **computer program** or just **program.**
- Example programs or software:
  - Word processing program
  - Computer Games or video games

Program Development

- **Edit** : Program is created in the editor and stored on disk.
- **Pre-process** : Pre-process program processes the code.
- **Compile** : Compiler creates object code and stores it on disk.
- **Link** : Linker links the object code with the libraries.
- **Load** : Loader loads program in memory.
- **Execute** : CPU takes each instruction and executes it.

Preprocess Directive

Header File

Return Type

Main Function

Body

```
#include<stdio.h>

int main()
{
    printf("I am learning C");
    return 0;
}
```

5

First C Program

C program to print a line of text

C Character Set

- You write your C program by using some characters.
- These characters are:
  - Alphabets (Uppercase & Lowercase)
  - A, B, C………………….., X, Y, Z.
  - a, b, c …………………..., x, y, z.
  - Digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9)
  - Special symbols (~ ` ! @ # $ % ^ & * ( ) _ -+ = | \}] [{ ; : ' " / ? . > , <)

Escape Sequence

7

Character	Escape Sequence	ASCII Value
Newline	\n	10
Horizontal Tab	\t	9

8

Day 2

Identifiers, Data Type, Memory Representation, Integer Data Type, how to use variable.

Identifiers

9

- Identifiers are names given to **variables, functions, arrays** and other programming elements.
- Used to uniquely identify each element.
- Rules to create identifiers
  - Can contain **alphabets, digits and underscore (_).**
  - First character must be an alphabet or underscore.
  - Space and other special symbols are not allowed.

Example of Identifiers

10

Correct	Incorrect
First_name	First name
a1	1a
area_of_circle	area of circle
Pi	^
TABLE	“TABLE”
_area	-area

Keywords

11

- **Keywords** are reserved words.
- Have standard, predefined meaning.
- Cannot be used as identifier.

Keywords

12

auto	extern	sizeof	break	float
static	case	for	struct	char
goto	switch	const	if	sizedef
continue	int	union	default	long
unsigned	do	register	void	double
return	volatile	else	short	while
enum	signed			

Data Types

13

- There are several data types in C.
- **Memory representation** of each data type is different.
- **Memory requirement** is also different.
- **Range** of each data type varies from data type to data type.

Some Data Types

14

- Character (**char**)
- Integer (**int**)
- Floating point (**float**)
- Valueless (**void**)

Integer

15

- Integer can be any number.
- Integer: 2 bytes (16 bit) or 4 bytes (32 bit).
  - 16 bit means 2^{16}= 65536 numbers.
    - Range (-32768 to 32767)
  - 32 bit means 2^{32}= 4,29,49,67,296 numbers.
    - Range (-2147483648 to 2147483647)
- Represent with "int" in C programs.
- Format specifier: %d

Working with Integer

16

- Declare an integer type variable.
  - int i;
- Initialize it with a value.
  - i = 10;
- Use it in program.
  - printf("%d" , i);

Integer Constant

17

- Must have at least one digit.
- Decimal point is not allowed.
- Can be positive or negative default is positive.
- Commas, blanks or any other symbol is not allowed.
- **Correct:** 12 -467 +098
- **Incorrect:** 12,120 12-10 13.09

18

Day 3

Scanf, Arithmetic Instructions,

Scanf Function

19

- Used to take input from user.
- Syntax:
- scanf("%d", &variable);

Arithmetic Operators

20

- * : multiplication
- / : division
- + : addition
- - : subtraction
- % : modulus operator
- Variable = constant;
  - –x = y + z;

Result of each Operator

21

- Result of each operator
- 2 * 3 = 6
- 4 / 2 = 2
- 4 + 2 = 6
- 4 –2 = 2
- 4 % 3 = 1
- 4 % 2 = 0

Assignment Operator =

22

- Assign expression value to an identifier.
- **identifier = expression** or **variable = constant.**
- Multiple assignment execute from **right to left.**
  - Ex**:** x=y=z=5.

More Assignment Operator…

23

- *=, /=, %=, +=, -= known as compound assignment operator.
- x+=1; means x=x+1;
- a-=b; means a=a–b;
- **m % = (n – 7);** means **m = m % (n – 7);**

Unary Operators

24

- Operate upon single operand.
- - (unary minus)
- + (unary plus)
- -- (decrement operator) : decrement by 1
  - i--; or --i; equal to i = i -1;
- ++ (increment operator) : increment by 1
  - **i++;** or **++i;** equal to **i= i+1;**

Operator precedence

25

Operator	Operation	Precedence
( )	Parentheses	Evaluate First, Left to Right
-, +, --, ++	Unary Operators	Right to left
*, / , %	Multiplication, Division or Modulus	Left to Right
+ or -	Addition or Subtraction	Left to Right
=	Assignment	Right to Left

Example of Precedence

26

- a = 2 * 3 / 4 + 4 / 4 + 8 –2 + 5 / (3 + 1)

Branching Statement 1

30

- If statement
- General Form:

```
if(condition)
    statement;
```

- if Condition is true (non-zero), the statement will be executed.
- if the condition is false (0), the statement will not be executed.

27

Day 4

Relational Operators, Equality Operators, Branching Statement, If, if-else

Need

28

- Write a program which take a number as input and print it if it is an even number.

Branching Statement

- We use branching statement to change the control flow of a program.
- Branching statement cause one section of code to be executed or not executed, depending on a conditional clause.

An Example

- Write a program which take a number as an input and print it if it is an even number.
- == Is a relational operator that represents “equal to”.

```
2  if(number % 2 == 0)
3      printf("%d",number);
```

- Line number 3 will execute only if condition is true(non-zero)
- Line number 3 will not execute if condition is false(Zero)

Relational Operator

Operator	Meaning
==	Equal to
!=	Not Equal to
>=	Greater than or equal to
>	Greater than
<=	Less than or equal to
<	Less than

Operator Precedence

Operator	Operation	Precedence
( )	Parentheses	Evaluate First, Left to Right
-, +, --, ++	Unary Operators	Right to left
*, / , %	Multiplication, Division or Modulus	Left to Right
+ or -	Addition or Subtraction	Left to Right
<, <=, >, >=	Relational Operator	Left to Right
==, !=	Equality Operator	Left to Right
=	Assignment	Right to Left

Multiple Statements

- Put all statements inside the curly { } braces.

```
if(condition)
{
    statement 1;
    statement 2;
    statement 3;
}
```

More Examples

- Input cost price and selling price of an item through the keyboard and write a program to determine the profit or loss.
- Write a program to determine whether the year (input from keyboard) is a leap or not.

Branching Statement 2

36

- Else statement
- An alternate form of if statement

```
if(condition)
    statement 1;
else
     statement 4;
```

```
if(condition)
{
    statement 1;
    statement 2;
    statement 3;
}
else
{
     statement 4;
     statement 5;
     statement 6;
}
```

Problem

37

- Write a program which take two sides of a rectangle and determine whether the given sides are of a rectangle or a square.

38

Day 5

Functions, Function call, pass by value, return types.

Function

39

- Allow us to group commonly used code into a compact unit that can be used repeatedly.
- `main()` function is must in each program.
- Other functions call directly or indirectly from `main()`.

Consider a problem

40

- Write a program that take 3 numbers x, y, z as input from user and calculate and print $x^5+y^5+z^5$

General Form

41

```
return_type function_name(parameters)
{
     statement;
     return value;
}
```

- **Return type:** any data type.
- **Function name:** used to call the function.
- **Parameters:** zero or more variables.

Example

42

- This function accept an integer value and return its square.

```
int square(int num)
{
     num *= num;
     return num;
}

return_type function_name(parameters)
{
     statement;
     return value;
}
```

Function Call

43

- Pass function name and Parameters.
- Function performs a specific task that is given to it.
- Result will return.
- Default return type is int.
- If you want to return noting use void.

More about function

44

- All variable defined inside functions are local and known only in function defined.
- Parameters are used to communicate between functions.

Problems

45

- Write a function that return the maximum value among three integers.
- Write a function to determine whether the year is leap or not.

Scope of Variable

46

- Variable declared inside a function can be used inside that function body only.

Call by Value

47

- Call by value
  - Copy of arguments passed to function.
  - Change in variable inside function do not effect original.

48

Day 6

Recursion

Recursion

49

- Recursion involves the situation in which a function calls itself.
- It must have a well-defined base-case.
- Must have well-defined steps that lead to the stopping state.

Example from Maths

50

$$f(x) = \begin{cases} x + f(x-1) & \text{if } x > 1 \\ x & \text{if } x = 1 \end{cases}$$

```
int ap(int num)
{
    if(num == 1) return num;
    num = num + ap(num - 1);
    return num;
}
```

What to answer

51

- How many calls have been made to recursive function?
- How many returns have been made from recursive function?
- Identify base case from a given program.

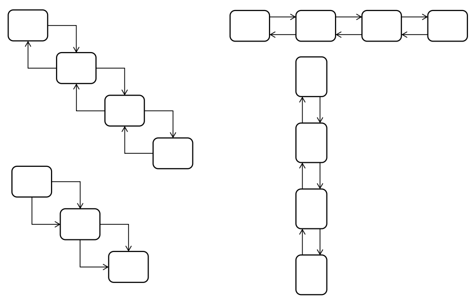
Problems to Solve

52

- Pow(n)
- Countdown(n)
- Countup(n)
- Factorial(n)

Graphical Representation

53



Appendix III: Source code used in RC4 and RC5

first.c

```
#include<stdio.h>

int main()
{
    printf("I am learning C.");
    return 0;
}

```

escape.c

```
#include<stdio.h>

int main()
{
    printf("*\n**\n***\n****\n*****");
    return 0;
}

```

identifier.c

```
#include<stdio.h>

int main()
{
    int return0;
    return 0;
}

```

integer.c

```
#include<stdio.h>

int main()
{
    int i;   //Declaration
    i = 20000; //initialization
    printf("%d",i); //Use
    return 0;
}

```

scanf.c

```
#include<stdio.h>

int main()
{
    int i;
    scanf("%d",&i);
    printf("%d",i);
    return 0;
}

```

arithmetic.c

```
#include<stdio.h>

int main()
{
    int i,j,k;
    scanf("%d %d",&i,&j);
    k = i % j;
    printf("%d",k);
    return 0;
}

```

compound.c

```c
#include<stdio.h>

int main()
{
    int i;
    scanf("%d",&i);
    i*=5;
    printf("%d",i);
    return 0;
}
```

unary.c

```c
#include<stdio.h>

int main()
{
    int i=5,j;
    j = ++i;
    printf("%d",2*3/4+4/4+8-2+5/(3+1));
    return 0;
}
```

need.c

```c
#include<stdio.h>

int main()
{
    int i;
    scanf("%d",&i);
    if( i%2 == 0)
        printf("%d",i);
    return 0;
}
```

profitloss.c

```c
#include<stdio.h>

int main()
{
    int cp,sp;
    scanf("%d %d",&cp,&sp);
    if(cp < sp)
    printf("Profit");
    if(cp > sp)
    printf("Loss");
    return 0;
}
```

relational.c

```c
#include<stdio.h>

int main()
{
    printf("%d",5<=6);
    return 0;
}
```

multiplestmt.c

```c
#include<stdio.h>

int main()
{
    if(1)
    {
        printf("Statement 1");
        printf("Statement 2");
    }
    return 0;
}
```

assignvsequal.c

```c
#include<stdio.h>

int main()
{
    int a = 7;
    if(a = 8)
        printf("%d",a);
    return 0;
}

```

ifelse.c

```c
#include<stdio.h>

int main()
{
    int cp,sp;
    scanf("%d %d",&cp,&sp);
    if(cp < sp)
    printf("Profit");
    else
    printf("Loss");
    return 0;
}

```

rectangle.c

```c
#include<stdio.h>

int main()
{
    int side1,side2;
    scanf("%d %d",&side1,&side2);
    if(side1 == side2)
    printf("Square");
    else
    printf("Rectagle");
    return 0;
}

```

functionneed.c

```c
#include<stdio.h>

int pow5(int i)
{
    return i*i*i*i*i;
}

int main()
{
    int x,y,z;
    scanf("%d %d %d",&x,&y,&z);
    printf("%d",pow5(x)+pow5(y)+pow5(z));
    return 0;
}

```

linebreak.c

```c
#include<stdio.h>

void line_break()
{
    printf("\n=========\n");
}

int main()
{
    printf("Hello");
    line_break();
    printf("World");
    line_break();
    printf("Yogendra");
    return 0;
}

```

max.c

```
#include<stdio.h>

int max(int x, int y, int z)
{
    if(x>y)
        if(x>z)  return x;
        else     return z;
    else
        if(y>z)  return y;
        else     return z;
}

int main()
{
    int x,y,z;
    scanf("%d %d %d",&x,&y,&z);
    printf("%d",max(x,y,z));
    return 0;
}
```

square.c

```
#include<stdio.h>

int square(int i)
{
    i *= i;
    return i;
}

int main()
{
    int x,y,z;
    scanf("%d %d %d",&x,&y,&z);
    printf("%d",square(x)+square(y)+square(z));
    return 0;
}
```

day6_batch1.c

```c
#include<stdio.h>

int ap(int num)
{
    if(num == 1) return num;
    num = num + ap(num-1);
    return num;
}

int main()
{
    printf("%d",ap(5));
    return 0;
}

```

day6_batch1_2.c

```c
#include<stdio.h>

int power(int x, int y)
{
    if(y == 1) return x;
    if(y == 0) return 1;
    x = x * power(x,--y);
    return x;
}

int main()
{
    int x,y;
    scanf("%d %d",&x,&y);
    printf("%d",power(x,y));
    return 0;
}

```

day6_batch1_3.c

```c
#include<stdio.h>

int count_down(int num)
{
	if(num <= 0)  return num;
	printf("%3d  ",num);
	num = count_down(num - 5);
	return num;
}

int main()
{
	printf("%d",count_down(1000));
	return 0;
}

```

multi_recursively.c

```c
#include<stdio.h>

int fact(int num)
{
	if(num == 1)  return num;
	num = num * fact(num - 1);
	return num;
}

int main()
{
	printf("%d",fact(5));
	return 0;
}

```

Appendix IV: Pre and Post-test for RC4 & RC5

Pre-Test

Q1. What will be the output of following program?

```c
#include<stdio.h>

int main()
{
    int i;
    i = 5;
    printf("%d",i);
    return 0;
}
```

…………………………………………………

Q2. \n & \t are

a. Keywords
b. Escape Sequence
c. Format Specifier
d. None of the above

Q3. If int a = 3, int b=4, int c = 1 than what will be the value of d?
int d = a * (b + c);

……………………………………………………………

Q4. What will be the value of i if?
int i = 5 == 6;

……………………………………………………………

Q5. What will be the output of following program?

```c
#include<stdio.h>

int main()
{
    int i = 5;
    if (i==5)
    {
     printf("If");
    }
    return 0;
}
```

……………………………………………………………

Q6. What will be the output of following program?

```c
#include<stdio.h>

int main()
{
    int i=5, j=6;

    print(i,j);
    return 0;
}

print(int k, int l)
{
    printf("%d %d",k,l );
}
```

……………………………………………………………

Q7. What will be the output of following program?

```c
#include<stdio.h>

int main()
{
    int i=5, j=6, k;

    k = min(i,j);
    printf("%d",k);
    return 0;
}

int min(int a, int b)
{
    a = a + b;
    return a;
}
```

……………………………………………………………

Q8. What will be the output of following program?

```c
#include<stdio.h>

int main()
{
    int i=5, j=6;

    if(i < j)
        printf("%d",i);

    return 0;
}
```

....

Q9. How many calls have been made to count function in the following program?

```c
#include<stdio.h>

void count(int p)
{
    if(p==0) return;

    printf("%d",p);
    count(p-1);
    return;
}


int main()
{
    count(10);
    return 0;
}
```

a. 10

b. 11

c. 9

d. None of the above

Q10. What will be the output of following program?

```c
#include<stdio.h>

void count(int p)
{
    if(p==0) return;

    printf("%d",p);
    count(p-1);
    return;
}


int main()
{
    count(10);
    return 0;
}
```

....

Post Test: Day 1 & 2

Q1. What will be the correct sequence of the following program?

```
1 return 0;
2 }
3 int main()
4 #include<stdio.h>
5 {
```

a. 4 3 5 1 2

b. 4 5 3 1 2

c. 5 3 2 4 1

d. None of the above

Q2. What will be the output of following program?

```
#include<stdio.h>

int main()
{
    printf("One\nTwo");
    return 0;
}
```

a. One\nTwo

b. One
Two

c. One Two

d. None of the above

Q3. What will be the output of following program?

```
#include<stdio.h>

int main()
{
    printf("One\tTwo");
    return 0;
}
```

a. One\tTwo

b. One
Two

c. One Two

d. None of the above

Q4. Identify correct identifiers.

a. Your name [ ]

b. Greatest_number [ ]

c. 1st_position [ ]

d. minimum-marks [ ]

e. %age [ ]

f. _max [ ]

g. Wrong_identifier [ ]

h. –min [ ]

Q5. \n & \t are

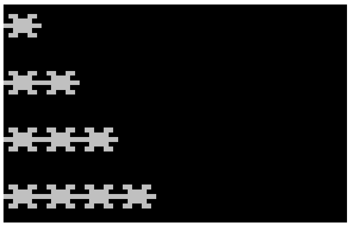
a. Keywords

b. Escape Sequence

c. Format Specifier

d. None of the above

Q6. Write a program using one printf statement to print the pattern of asterisks as shown below:



Q7. Circle the word that defines the return type of main function.

```
#include<stdio.h>

int main()
{
    printf("I am learning C");
    return 0;
}

```

Q8. What will be the output of following program?

```
#include<stdio.h>

int main()
{
    printf("I am learning C");
    return 0;
}

```

………………………………………………………………………………………

Q9. What is the correct sequence of working with a variable?

a. Initialize -> Declare -> Use

b. Declare -> Use -> Initialize

c. Declare -> Initialize -> Use

d. Use -> Declare -> Initialize

Q10. What will be the output of following program?

```
#include<stdio.h>

int main()
{
    int i;
    i = 5;
    printf("%d",i);
    return 0;
}
```

…………………………………………………………………………………………

Post Test: Day 3

Q1. %d is a

a. Escape sequence
b. Format specifier
c. Keyword
d. None of the above

Instruction: Read the following program and answer Q2a to Q2c.

```
1  #include<stdio.h>
2
3  int main()
4  {
5      int a,b,c;
6      b = 4;
7      c = 8;
8      a = b + c / 2;
9      printf("%d",a);
10     return 0;
11 }
```

Q2a. How many variables are there in the following program?

a. 2
b. 3
c. 4
d. 1

Q2b. What will be the output of following program?

a. 6
b. 8
c. 0
d. None of the above

Q2c. Declaration of variable is in line?

a. 6
b. 7
c. 5
d. 9

Q3. What will the value of I?
I = 23 % 4;

a. 5
b. 23
c. 0
d. 3

Q4. What will be the value of J?
J = 2 * ((8 / 6) + (4 * (9 – 4)) % (3 * 2 – 2);

Q5. What will be the value of K if?
K = 45;
K += 5;

a. Equation is Wrong
b. 45
c. 50
d. None of the above

Q6. What will be the output of following program?

```
#include<stdio.h>

int main()
{
    int side=5;
    side *= side;
    printf("%d", side);
    return 0;
}
```

a. Error
b. 5
c. 25
d. Garbage value

Q7. What will be the value of L if?
a = 9;
L = ++a;

a. 10
b. 9
c. 11
d. Other please write ……………………………

Q8. What will be the output of following program?

```
#include<stdio.h>

int main()
{
    int side=5, M;
    M = ++side;
    printf("%d %d\n", M,side);
    M = ++side;
    printf("%d %d", M,side);
    return 0;
}
```

a. 5 5
   6 6
b. 6 6
   7 7
c. 5 6
   6 7
d. None of the above

Post Test: Day 4

Q1. What will be the output of following program?

```c
#include<stdio.h>

int main()
{
    if(1)
        printf("Statement 1");
    printf("Statement 2");
}
```

a. Statement 1 Statement 2
b. Statement 1
c. Statement 2
d. Nothing will print

Q2. What will be the output of following program?

```c
#include<stdio.h>

int main()
{
    if(1)
        printf("Statement 1");
        printf("Statement 2");
}
```

a. Statement 1 Statement 2
b. Statement 1
c. Statement 2
d. Nothing will print

Q3. What will be the output of following program?

```c
#include<stdio.h>

int main()
{
    if(0)
        printf("Statement 1");
        printf("Statement 2");
}
```

a. Statement 1 Statement 2
b. Statement 1
c. Statement 2
d. Nothing will print

Q4. What will be the output of following program?

```c
#include<stdio.h>

int main()
{
    if(1)
    {
        printf("Statement 1");
        printf("Statement 2");
    }
    printf("Statement 3");
}

```

a. Statement 1 Statement 2 Statement 3
b. Statement 1 Statement 2
c. Statement 2 Statement 3
d. Statement 3
e. Other please write

……………………………………………………
…………………………

Q5. What will be the output of following program?

```c
#include<stdio.h>

int main()
{
    int a = 7;
    if(a = 8)
    {
        printf("%d\t",a);
        a = 9;
    }
    printf("%d",a);
    return 0;
}
```

a. 7
b. 8 9
c. 7 8
d. 7 9
e. Other please write ……………………………………

Q6. What will be the output of following program?

```c
#include<stdio.h>

int main()
{
    int a = 7;
    if(a == 8)
    {
        printf("%d\t",a);
        a = 9;
    }
    printf("%d",a);
    return 0;
}
```

a. 7
b. 8 9
c. 7 8
d. 7 9
e. Other please write……………………………………………

Q7. What will be the output of following program?

```c
#include<stdio.h>

int main()
{
    int a = 100,b = 100;
    if(a > b)
    {
        printf("%d\t",a);
    }
    b+=10;
    printf("%d",b);
    return 0;
}
```

a. 100 100

b. 100 110
c. 110
d. 110 100
e. Other please write
……………………………………..

Q8. Value of K if?
K = 5 == 6
a. 6
b. 5
c. 0
d. 1
e. Other please write
………………………………………

Q9. What will be Value of L in following equation?
L = 5 <= 6
a. 6
b. 5
c. 1
d. 0
e. Other please write
………………………………………

Q10. Value of L if?
L = 5 > 5
a. 5
b. 1
c. 0
d. Other please write
………………………………………

Q11. Value of L if?
L = 6 != 5
a. 6
b. 5
c. 1
d. 0
e. Other please write
………………………………………

Q12. Which relational operator should be used in line number 6 in order to print “Loss” as output.

```
1  #include<stdio.h>
2
3  int main()
4  {
5      int a = 100,b = 20;
6      if(a ..... b)
7          printf("Loss");
8      else
9          printf("Profit");
10     return 0;
11 }
```

a. >
b. <
c. >=
d. <=
e. a and c both can be used
f. Other please write
……………………………….

Q13. Write a program to take an input from user and print it if it is an even number.

Q14. What will be the output of following program?

```
#include<stdio.h>

int main()
{
    int i=5, j=6;

    if(i < j)
        printf("%d",i);

    return 0;
}
```

a. 5
b. 6
c. Nothing will print
d. Other please write
……………………………………….

Q15. What will be the output of following program?

```
#include<stdio.h>

int main()
{
    int i = 5;
    if (i==5)
    {
     printf("If");
    }
    return 0;
}
```

a. If
b. “If”
c. Nothing will print
d. Other please write
………………………………………..

Q16. Match the following

Relational Operator	%
Equality Operator	>=
Unary Operator	=
Arithmetic Operator	==
Assignment Operator	++

Post test : Day 5

Q1. Answer Q1a to Q1e from the given program.

```
1  #include<stdio.h>
2
3  int square(int num)
4  {
5      num *= num;
6      return num;
7  }
8
9  int main()
10 {
11     printf("%d",square(5));
12     return 0;
13 }
```

Q1a. Function 'square' is called from line number?

a. 3
b. 6
c. 11
d. No call to function square is made
e. Other please write ……………………………….

Q1b. Function 'square' is returning value from line?

a. 3
b. 6
c. 11
d. 12
e. Other please write ……………………………..

Q1c. What will be the value of variable 'num' when control of program reaches to line number 3.

a. 5
b. 25
c. 10
d. Other please write …………………………..

Q1d. What will be the output of this program?

a. 5
b. 25
c. 10
d. Nothing will print
e. Other please write ……………………………..

Q1e. What will be the control flow of 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 ……………………………………

Q2. What will be the output of following program?

```
#include<stdio.h>

int main()
{
    int i=5, j=6;

    print(i,j);
    return 0;
}

print(int k, int l)
{
    printf("%d %d",k,l );
}
```

a. 5 6
b. 6 5
c. Error
d. Nothing will print
e. Other please write ……………………………….

Q3. What will be the output of following program?

```
#include<stdio.h>

int main()
{
    int i=5, j=6, k;

    k = min(i,j);
    printf("%d",k);
    return 0;
}

int min(int a, int b)
{
    a = a + b;
    return a;
}
```

a. 5
b. 11
c. Error
d. Other please write …………………………………
e. Nothing will print

Q4. What is the output of following program?

```c
#include<stdio.h>

int max(int a, int b)
{
     if(a>b) return a;
     else return b;
}

int main()
{
     int a = 6,b = 8, maximum;
     maximum = max(a,b);
     printf("%d",maximum);
     return 0;
}
```

a. Error, variable a & b are declared in both functions.
b. Error, function max has two return function.
c. 8
d. Other please write ……………………………………….

Q5. What will be the output of following program?

```c
#include<stdio.h>

void line_break()
{
     printf("\n=====::::=====\n")
}

int main()
{
     printf("Hello");
     line_break();
     printf("World");
     return 0;
}
```

a. Error, no parameter is passed to the function line_break.
b. Error, function line_break has no return statement
c. Hello
   =====::::=====
   World
d. No output
e. Other please write ……………………………………….

Q6. What will be the output of following program?

```c
#include<stdio.h>

void line_break()
{
     printf("\n=====::::=====\n")
}

int main()
{
     printf("Hello");
     printf("World");
     return 0;
}
```

a. Error, function line_break is not called.
b. Error, function line_break has no return statement
c. Hello
   =====::::=====
   World
d. No output
e. Other please write ……………………………………….

Post Test: Day 6

Q1. Look at following function and answer Q1a - Q1d.

$$f(x,y)=\begin{cases} f(x-y,y+1)+2 & x>y \\ x+y & otherwise \end{cases}$$

Q1a. Is this function recursive? [-1 if answered incorrectly]

a. Yes
b. No

Q1b. Circle the base case in the function.

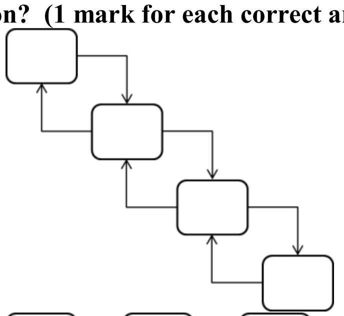
Q1c. What will be the value of f(12,6)

a. 13
b. 15
c. 18
d. Other please write ……………………………………….

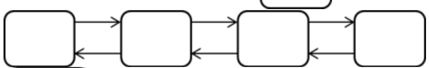
Q1d. How many time(s) f(x,y) will run to solve f(12,6)

a. 1
b. 3
c. 2
d. Other please write …………………………………..

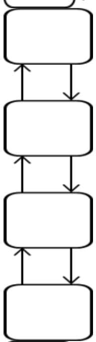
Q3. What is/are the correct memory model for recursion? (1 mark for each correct answer)



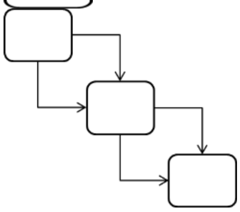
a.



b.



c.



d.

Q3. Hand Execute the following program at the back side of this page and answer Q3a - Q3e.

```c
#include<stdio.h>

int ap(int num)
{
    if(num <= 1) return num;
    num = num + ap(num - 2);
    return num;
}

int main()
{
    printf("%d",ap(5));
    return 0;
}
```

Q3a. Is function ap() recursive? [-1 if answered incorrectly]

a. Yes
b. No

Q3b. Circle the base case in the program.

Q3c. What is the output of this program?

a. 15
b. 9
c. 16
d. Garbage
e. Other please write …………………………………..

Q3d. How many calls have been made for function ap() in this program?

a. 3
b. 5
c. 6
d. 0
e. Other please write ……………………………………….

Q3e. How many returns have been made from function ap().

a. 5
b. 6
c. 0
d. 3
e. Other please write …………………………………..

Q4. A function is recursive if it calls ………………………..?

Q5. A recursive function must have a …………….. case.

Q6. Write a recursive function that count down to 1 from the number passed to it. (5 marks)

Appendix V: Topics covered in RC5

Table V.1 Deatils of segments and topics used in RC5

Major Start Time	minor start time	minor end time	Major end time	Content Type	Topics to teach
Day 1					
00:00:10			00:02:58	Concept	Computer
00:02:58			00:03:54	Concept	Computer Program
00:03:54			00:15:35	Procedure	How to write a computer program
	00:10:24	00:11:32		Procedure	Interface of code::blocks compiler
	00:12:07	00:15:33		Procedure	How to write and compile a program in code::blocks
00:15:33			23:22	Process	How does a program compile
00:23:22			00:24:09	Fact	C character set
00:24:09			00:28:14	Concept	Escape sequence
	00:25:37	00:28:11		Procedure	How to use /n /t in computer program
Day 2					
00:21:00			00:07:43	Concept	What is an identifier?
	00:01:47	00:04:12		Fact	What are the rules to create identifier?

	00:04:25	00:04:46		Procedure	Use code::blocks IDE
00:07:43			00:10:20	Concept	What are keywords?
00:10:20			00:16:00	Concept	What is data and why various data types are required.
	00:13:31	00:14:41		Fact	What is char data type?
	00:14:41	00:15:04		Fact	What is integer data type?
	00:15:04	00:15:41		Fact	What is floating point number?
	00:15:41	00:16:00		Fact	What is void data type?
00:16:16			00:17:32	Fact	What are the range of integer variable for 16 bit and 32 bit?
00:17:32			00:25:46	Procedure	How to create & access an integer type data in c program?
	00:20:15	00:23:17		Concept	What is garbage value?
00:25:46			00:28:42	Fact	Facts one should know before using integer constant
Day 3					
00:00:14			00:04:15	Fact	What does scanf() do?
	00:02:45	00:03:25		Procedure	How to use scanf()?
	00:03:25	00:04:15		Process	How does scanf() works?
00:04:21			00:14:19	Fact	What arithmetic operators can be used in c program?
	00:05:00	00:06:24		procedure	How to make arithmetic equation in a c program?
	00:06:46	00:07:37		process	How does a modulus operator work?
	00:09:27	00:14:19		process	How does compiler solve arithmetic equations?
00:14:19			00:15:02	Fact	What is assignment operator?
00:15:02			00:17:57	process	How does multiple assignment execute?

00:17:57			00:21:07	Concept	What is compound assignment operator?
	00:20:06	00:21:03		Procedure	How to use compound assignment operators?
00:21:08			00:28:52	Concept	Unary operator
	00:22:32	00:23:38		Fact	Decrement and increment operator
	00:23:57	00:25:18		procedure	How to use increment and decrement operator in c program.
	00:25:18	00:28:52		Process	How does pre and post decrement / increment operator works?
00:28:52			00:31:30	Fact	Operator precedence
Day 4					
00:00			00:04:50	Concept	Branching Statement
	00:03:40	00:04:26		Fact	Facts about branching statement
00:04:50			00:15:17	Process	How does a if statement works?
	00:05:08	00:05:42		Procedure	How to write if statement?
	00:09:45	00:12:01		Fact	"==" relational operator
00:15:17			00:23:15	Fact	Work of various relational operators
	00:18:15	00:19:27		Process	How does == work?
	00:19:27	00:20:22		Process	How does != work?
	00:20:24	00:20:49		Process	How does > work?
	00:20:50	00:21:17		Process	How does >= operator work?
	00:21:17	00:21:32		Process	How does < operator work
	00:21:32	00:23:00		Process	How des <= operator work
00:23:15			00:24:05	Fact	Operator precedence

00:24:09			00:28:50	Procedure	How to write multiple statements in if statement?
	00:27:32	00:28:50		Process	How does if statement with multiple line work?
00:29:00			00:35:50	Principle	Solving a programming problem that has conditions
00:35:52			00:37:55	Fact	Else statement
	00:36:16	00:36:42		Procedure	How to write if-else statement?
	00:36:42	00:37:09		Process	How does if-else statement work
	00:37:09	00:37:25		Procedure	How to write if-else statement with multiple statements
	00:37:25	00:37:55		Process	How does if-else statement with multiple line works?
00:37:55			00:45:25	Principle	Using if-else statements for programming problems.
	00:38:32	00:40:00		Process	How does compiler execute if-else statement?
	00:43:00	00:45:25		Process	How does compiler execute if statement with assignment and equal-to operator
Day 5					
00:00:11			00:18:11	Concept	Function
	00:06:28	00:11:36		Procedure	How to create and use a function in c?
	00:11:36	00:18:11		Process	How does a c program with functions execute in c?
	00:21:00	00:21:33		Fact	Some facts about function call
	00:21:45	00:24:21		Process	How does a c program with function works when it's returing nothing
	00:24:25	00:26:00		Concept	Scope of variable
00:26:00			00:30:10	Principle	Building c programs with functions.

00:30:42			00:32:32	Concept	Call by value
Day 6					
00:00:06			00:16:11	Concept	Recursion
	00:02:40	00:06:00		Procedure	How to solve a mathematical recursive function
	00:06:00	00:08:44		Procedure	Convert a mathematical recursive function into a recursive function in c
	00:08:44	00:14:34		Procedure	How to hand execute a recursive function
00:16:11			00:21:40	Principle	How to solve programming problems using recursive function

References

Apperson, J. M., Laws, E. L., & Scepansky, J. A. (2008). An assessment of student preferences for PowerPoint presentation structure in undergraduate courses. *Computers & Education*, *50*(1), 148–153. http://doi.org/10.1016/j.compedu.2006.04.003

Ayres, P., Marcus, N., Chan, C., & Qian, N. (2009). Learning hand manipulative tasks: When instructional animations are superior to equivalent static representations. *Computers in Human Behavior*, *25*(2), 348–353.

Beed, P. L., Hawkins, E. M., & Roller, C. M. (1991). Moving Learners toward Independence: The Power of Scaffolded Instruction. *The Reading Teacher*, *44*(9), 648–655.

Berthele, R. (2012). The influence of code-mixing and speaker information on perception and assessment of foreign language proficiency: An experimental study. *International Journal of Bilingualism*, *16*(4), 453–466. http://doi.org/10.1177/1367006911429514

Bhardwaj, B. K., & Pal, S. (2012). Data Mining: A prediction for performance improvement using classification. *arXiv Preprint arXiv:1201.3418*.

Bowers, J., Dent, J., & Barnes, K. (2009). Video Tutorials: A Sustainable Method for Campus Technology Training. *Educause Quarterly*.

Brush, T. A., & Saye, J. W. (2002). A summary of research exploring hard and soft scaffolding for teachers and students using a multimedia supported learning environment. *The Journal of Interactive Online Learning*, *1*(2), 1–12.

Chaudron, C. (1988). *Second language classrooms: Research on teaching and learning*. Cambridge University Press.

Cheney, G. R., Ruzzi, B. B., & Muralidharan, K. (2005). A profile of the Indian education system. *Prepared for the New Commission on the Skills of the American Workforce*.

Cheney, G., Ruzzi, B., & Muralidharan, K. (2005). A profile of the Indian education system. *National Centre On Education And The Economy*, (November 2005), 29.

Clark, R. C. (2011). *Developing technical training: A structured approach for developing classroom and computer-based instructional materials*. John Wiley & Sons.

Clark, R. C., & Lyons, C. (2004). *Graphics for learning*. *Graphics for Learning: Proven Guidelines for Planning, Designing, and Evaluating Visuals in Training Materials* (Second Edi).

Clark, R., & Mayer, R. (2011). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*.

Cohen, L., Manion, L., & Morrison, K. (2000). Action research. *Conducting Small Scale Investigations in Educational Management*.

Dabbagh, N. (2003). Scaffolding: An important teacher competency in online learning. *TechTrends*.

de Koning, B. B., Tabbers, H. K., Rikers, R. M. J. P., & Paas, F. (2007). Attention cueing as a means to enhance learning from an animation. *Applied Cognitive Psychology*, *21*(6), 731–746. http://doi.org/10.1002/acp.1346

de Koning, B. B., Tabbers, H. K., Rikers, R. M. J. P., & Paas, F. (2011). Attention cueing in an instructional animation: The role of presentation speed. *Computers in Human Behavior*, *27*(1), 41–45. http://doi.org/10.1016/j.chb.2010.05.010

Ellis, C. (2008). “You Can”t Do That in a Classroom!’: How Distributed Learning Can Assist in the Widespread Adoption of Hybrid Learning Strategies. In J. Fong, R. Kwan, & F. Wang (Eds.), *Hybrid Learning and Education* (Vol. 5169, pp. 1–16). Springer Berlin Heidelberg. http://doi.org/10.1007/978-3-540-85170-7_1

Eranki, K. L. N., & Moudgalya, K. M. (2012). A collaborative approach to scaffold programming efficiency using spoken tutorials and its evaluation. *Collaborative Computing: Networking, Applications and Worksharing (CollaborateCom), 2012 8th International Conference on*, 556–559.

Fennema-Bloom, J. R. (2009). Code-scaffolding: A Pedagogic Code-switching Technique for Bilingual Content Instruction. *The Journal of Education*, *190*(3), 27–35.

García, O., & Sylvan, C. E. (2011). Pedagogies and practices in multilingual classrooms: Singularities in pluralities. *Modern Language Journal*, *95*, 385–400. http://doi.org/10.1111/j.1540-4781.2011.01208.x

Gaspar, A., & Langevin, S. (2007). Restoring “coding with intention” in introductory programming courses. *Proceedings of the 8th ACM SIGITE Conference on Information Technology Education*. Destin, Florida, USA: ACM. http://doi.org/10.1145/1324302.1324323

Genesee, F. (2004). What do we know about bilingual education for majority language students. *Handbook of Bilingualism and Multiculturalism*, 547–576.

Glass, G. V, & Hopkins, K. D. (1970). *Statistical methods in education and psychology*.

Prentice-Hall Englewood Cliffs, NJ.

Gómez, L., Freeman, D., & Freeman, Y. (2005). Dual language education: A promising 50–50 model. *Bilingual Research Journal*, *29*(1), 145–164.

Guo, P. J., Kim, J., & Rubin, R. (2014). How Video Production Affects Student Engagement : An Empirical Study of MOOC Videos. *L@S 2014 - Proceedings of the 1st ACM Conference on Learning at Scale*, 41–50. http://doi.org/10.1145/2556325.2566239

Gyselinck, V., & Tardieu, H. (1999). The role of illustrations in text comprehension: what, when, for whom, and why?

Hammond, J. (2001). *Scaffolding: Teaching and Learning in Language and Literacy Education*. ERIC.

Hanjing, L., Kuanquan, W., & Yuying, W. (2009). A Bilingual Teaching Modal in a Programing Language Course. In *Education Technology and Training, 2009. ETT '09. Second International Conference on* (pp. 197–200). http://doi.org/10.1109/ETT.2009.71

Hegarty, M., Narayanan, N. H., & Freitas, P. (2002). Understanding machines from multimedia and hypermedia presentations. *The Psychology of Science Text Comprehension*, 357–384.

Hmelo, C. E., & Guzdial, M. (1996). Of black and glass boxes: Scaffolding for doing and learning. In *Proceedings of the 1996 international conference on Learning sciences* (pp. 128–134). International Society of the Learning Sciences.

John L. FaLconer J. Will Medlin, and Michael P. Holmberg, J. deGrazia. (2009). Using ScreenCasts in ChE Courses, *43*(4).

Joint Task Force on Computing Curricula, A. for C. M., & Society, I. C. (2013). *Computer*

Science Curricula 2013: Curriculum Guidelines for Undergraduate Degree Programs in Computer Science. ACM.

Kalish, J. M. and A., & Middendorf A., J. & K. (1995). The "Change-up" in Lectures. *The National Teaching & Learning Forum*, *5*(2), 1–12. http://doi.org/10.1002/ntlf.10026

Kanetkar, Y. P. (2008). *Let us C*. Jones and Bartlett Publishers, Inc.

Kim, D.-J., Ferrini-Mundy, J., & Sfard, A. (2012). How does language impact the learning of mathematics? Comparison of English and Korean speaking university students' discourses on infinity. *International Journal of Educational Research*, *51-52*, 86–108. http://doi.org/10.1016/j.ijer.2012.01.004

Krippendorff, K. (2012). *Content analysis: An introduction to its methodology*. Sage.

Liu, S., Li, X., & Zuo, L. (2011). Adopting communicative teaching method in computer major bilingual teaching. *Theory and Practice in Language Studies*, *1*(2), 187–190.

Lloyd, S. A., & Robertson, C. L. (2012). Screencast Tutorials Enhance Student Learning of Statistics. *Teaching of Psychology*, *39*(1), 67–71. http://doi.org/10.1177/0098628311430640

Marcus, N., Cooper, M., & Sweller, J. (1996). Understanding instructions. *Journal of Educational Psychology*, *88*(1), 49.

Mautone, P. D., & Mayer, R. E. (2001). Signaling as a cognitive guide in multimedia learning. *Journal of Educational Psychology*, *93*(2), 377–389. http://doi.org/10.1037/0022-0663.93.2.377

Mayer, R. E., & Gallini, J. K. (1990). When is an illustration worth ten thousand words?

Journal of Educational Psychology, *82*(4), 715.

Mayer, R. E., & Moreno, R. (2003). Nine Ways to Reduce Cognitive Load in Multimedia Learning. *Educational Psychologist*, *38*(1), 43–52. http://doi.org/10.1207/S15326985EP3801_6

Mazak, C. M., & Herbas-Donoso, C. (2015). Translanguaging practices at a bilingual university: a case study of a science classroom. *International Journal of Bilingual Education and Bilingualism*, *18*(6), 698–714. http://doi.org/10.1080/13670050.2014.939138

McConnell, B. (1980). Does Bilingual Education Work? *Bilingual Resources*, *3*(2), 23–27.

McKenney, S., Nieveen, N., & van den Akker, J. (2006). Design research from a curriculum perspective. *Educational Design Research*, 67–90.

Mehisto, P. (2012). Criteria for Producing CLIL Learning Material. *Online Submission*.

Merrill, M. D., Drake, L., Lacy, M. J., Pratt, J., & Group, I. R. (1996). Reclaiming instructional design. *Educational Technology*, *36*(5), 5–7.

Mitra, S. K. (2010). Internationalization of Education in India: Emerging Trends and Strategies. *Asian Social Science*, *6*(6), p105. http://doi.org/http://dx.doi.org/10.5539/ass.v6n6p105

Mock, K. (2004). Teaching with Tablet PC’s. *J. Comput. Sci. Coll.*, *20*(2), 17–27.

Montague, N. (1997). Critical components for dual language programs. *Bilingual Research Journal*.

Moreno, R., & Mayer, R. E. (2002). Verbal redundancy in multimedia learning: When reading helps listening. *Journal of Educational Psychology*, *94*(1), 156.

Moses, M. S. (2000). Why Bilingual Education Policy Is Needed: A Philosophical Response to the Critics. *Bilingual Research Journal*, *24*(4), 333–354. http://doi.org/10.1080/15235882.2000.10162771

Newby, T. J., Ertmer, P. A., & Stepich, D. A. (n.d.). Instructional analogies and the learning of concepts. *Educational Technology Research and Development*, *43*(1), 5–18. http://doi.org/10.1007/BF02300478

Pal, Y., & Iyer, S. (2012). Comparison of English versus Hindi Medium Students for Programming Abilities Acquired through Video-Based Instruction. In *2012 IEEE Fourth International Conference on Technology for Education* (pp. 26–30). IEEE. http://doi.org/10.1109/T4E.2012.30

Pandharipande, R. (2002). Minority matters: issues in minority languages in India. *International Journal on Multicultural Societies*, (4.2), 213–234.

Plomp, & Tjeerd. (2013). *Educational design research: An introduction*.

Probyn, M. (2001). Teachers Voices: Teachers Reflections on Learning and Teaching through the Medium of English as an Additional Language in South Africa. *International Journal of Bilingual Education and Bilingualism*, *4*(4), 249–266. http://doi.org/10.1080/13670050108667731

Ravi, J., & Jani, H. J. (2011). A Critical Study of NPTEL. In *2011 IEEE International Conference on Technology for Education* (pp. 35–42). IEEE. http://doi.org/10.1109/T4E.2011.14

Ravi Pathiyil Shankar, A. K. D., y Mishra Pranaya, S. P., & Archana Saha, V. Y. D. (2005). Favorable Student Attitudes Towards Pharmacology in a Medical College in Western

Nepal . *JIAMSE*, *15*(31), 8.

Richards, J. C. (2013). Curriculum Approaches in Language Teaching: Forward, Central, and Backward Design. *RELC Journal*, *44*(1), 5–33. http://doi.org/10.1177/0033688212473293

Rubin, M. J. (2013). The effectiveness of live-coding to teach introductory programming. In *Proceeding of the 44th ACM technical symposium on Computer science education - SIGCSE '13* (p. 651). New York, New York, USA: ACM Press. http://doi.org/10.1145/2445196.2445388

Schmidt, R. (2000). *Language policy and identity politics in the United States*. Temple University Press.

Schnotz, W., Picard, E., & Hron, A. (1993). How do successful and unsuccessful learners use texts and graphics? *Learning and Instruction, 3*(3), 181–199.

Schwan, S., & Riempp, R. (2004). The cognitive benefits of interactive videos: learning to tie nautical knots. *Learning and Instruction*, *14*(3), 293–305. http://doi.org/10.1016/j.learninstruc.2004.06.005

Sercombe, P. (2003). Multilingualism among the Penans in Brunei. *International Journal of Bilingualism*, *7*(2), 153–175. http://doi.org/10.1177/13670069030070020301

Shannon, A., & Summet, V. (2015). Live Coding in Introductory Computer Science Courses. *J. Comput. Sci. Coll.*, *31*(2), 158–164.

Shuhidan, S., Hamilton, M., & D'Souza, D. (2010). Instructor perspectives of multiple-choice questions in summative assessment for novice programmers. *Computer Science Education*, *20*(3), 229–259. http://doi.org/10.1080/08993408.2010.509097

Simpson, N. (2006). Asynchronous access to conventional course delivery: a pilot project. *British Journal of Educational Technology*, *37*(4), 527–537. http://doi.org/10.1111/j.1467-8535.2006.00534.x

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction*, *4*(4), 295–312. http://doi.org/10.1016/0959-4752(94)90003-5

Sweller, J. (1999). Instructional Design in technical area. Australian Education Review. N 43. ACER Press, Melbourne.

Sweller, J., & AYRES, P. (2006). The split-attention principle in multimedia learning. *The Cambridge Handbook of Multimedia Learning. Cambridge: CUP. Págs*, 135–146.

Sweller, J., & Chandler, P. (1991). Evidence for Cognitive Load Theory. *Cognition and Instruction*, *8*(4), 351–362. http://doi.org/10.1207/s1532690xci0804_5

Tessmer, M. (1993). *Planning and conducting formative evaluations: Improving the quality of education and training*. Psychology Press.

Tew, A. E., & Guzdial, M. (2011). The FCS1: a language independent assessment of CS1 knowledge. In *Proceedings of the 42nd ACM technical symposium on Computer science education* (pp. 111–116). ACM.

Tollefson, J. W., & Tsui, A. B. M. (2003). *Medium of instruction policies: Which agenda? Whose agenda?* Routledge.

Toomela, A., & Valsiner, J. (2010). *Methodological thinking in psychology: 60 years gone astray?* IAP.

Turbak, F., Royden, C., Stephan, J., & Herbst, J. (1999). Teaching recursion before loops in

CS1. *Journal of Computing in Small Colleges*, *14*(4), 86–101.

van der Meij, H., Blijleven, P., & Jansen, L. (2003). What makes up a procedure. *Content & Complexity. Information Design in Technical Communication*, 129–186.

Venkatesan, D., Chandrasekaran, R., & Joseph, A. (2010). Significance of Medium of Instruction and Personality in Designing Adaptive e-Learning Systems. *Significance*.

Vygotsky, L. S. (1980). *Mind in society: The development of higher psychological processes*. Harvard university press.

Wademan, M. (2005). Utilizing development research to guide people capability maturity model adoption considerations.

Walqui, A. (2006). Scaffolding Instruction for English Language Learners: A Conceptual Framework. *International Journal of Bilingual Education and Bilingualism*, *9*(2), 159–180. http://doi.org/10.1080/13670050608668639

Watson, G., Butterfield, J., Curran, R., & Craig, C. (2010). Do dynamic work instructions provide an advantage over static instructions in a small scale assembly task? *Learning and Instruction*, *20*(1), 84–93.

Wiggins, G., & McTighe, J. (2001). What is backward design? In *Understanding by design* (1st editio, pp. 7–19). Merrill Prentice Hall.

Wong, A., Marcus, N., Ayres, P., Smith, L., Cooper, G. A., Paas, F., & Sweller, J. (2009). Instructional animations can be superior to statics when learning human motor skills. *Computers in Human Behavior*, *25*(2), 339–347.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal* *of Child Psychology and Psychiatry*, *17*(2), 89–100.

Yang, W. (2015). Content and language integrated learning next in Asia: evidence of learners' achievement in CLIL education from a Taiwan tertiary degree programme. *International Journal of Bilingual Education and Bilingualism, 18*(4), 361–382. http://doi.org/10.1080/13670050.2014.904840

Yau, J. C. (2011). Roles of mental translation in first and foreign language reading. *International Journal of Bilingualism, 15*(4), 373–387. http://doi.org/10.1177/1367006910380038

Yelland, N., & Masters, J. (2007). Rethinking scaffolding in the information age. *Computers & Education, 48*(3), 362–382.

List of publication

Publication related to thesis

Pal, Yogendra, and Sridhar Iyer. “Classroom Versus Screencast for Native Language Learners: Effect of Medium of Instruction on Knowledge of Programming.” Proceedings of the 2015 ACM Conference on Innovation and Technology in Computer Science Education. ACM, 2015.

Pal, Yogendra, and Sridhar Iyer. “Effect of medium of instruction on programming ability acquired through screencast.” Learning and Teaching in Computing and Engineering (LaTiCE), 2015 International Conference on. IEEE, 2015.

Pal, Yogendra, and Sridhar Iyer. “Comparison of English versus Hindi Medium Students for Programming Abilities Acquired through Video-Based Instruction.” Technology for Education (T4E), 2012 IEEE Fourth International Conference on. IEEE, 2012.

Other publication

Hubwieser, Peter et al. 2015. “A Global Snapshot of Computer Science Education in K-12 Schools.” Pp. 65–83 in Proceedings of the 2015 ITiCSE on Working Group Reports – ITICSE-WGR ’15. New York, New York, USA: ACM Press.

Anand, Abhinav et al. 2014. “Designing Engineering Curricula Based on Phenomenographic Results: Relating Theory to Practice.” Pp. 80–87 in 2014 IEEE Sixth International Conference on Technology for Education. IEEE.

Acknowledgement

First and foremost, I wish to express my utmost gratitude and heartfelt appreciation to my research advisor **Prof. Sridhar Iyer,** for his guidance**,** continuous support**,** motivation and discussion throughout the course of my research work. Without his advice this thesis would not have been possible. I thank **Prof. Sahana Murthy** for constant guidance for improving my thesis work. I also thank my Research Progress Committee member **Prof. Varsha Apte** and **Prof. Kinsukh** for their valuable inputs that helped me to improve my research work.

I thank **Mr. Ravin Pal, Mr. Raj Kumar Thenua, Mr. Vivek Pandey** and **Mr. Deependra Dwivedi** for their support and providing permission to conduct experiments with engineering graduates in the respective engineering institutes. I am grateful to all the students who accepted to participate in my studies. Their comments helped me to improve scaffolding framework constructively. I take the privilege to acknowledge my fellow researchers **Mr. Rwitajit Majumdar, Mr. Jayakrishnan Madathil Warriem, Mrs. Aditi Kothiyal** and **Mr. Shitanshu Mishra** for their help in brainstorming session during my work. I thank my wife **Mrs. Shalu Pal** for helping me in conducting student's interviews and experiments. I thank faculty members of **Anand Engineering College, Neelam college of Engineering, Chaudhary Beeri Singh College Of Engineering And Management, Mahatma Gandhi Mission's College Of Engineering & Technology, Ram-Eesh Institute of Engineering and Technology** to provide me the required facilities to conduct research in their colleges and help me during the experiments. I thank **Ms. Ranjna Pal, Mr. Ravin Pal, Mr. Vivek Pandey**, and **Mr. Deependra Dwivedi** to work as experts in the course of computer programming for my study. I am thankful to **Mrs. Uma Rao** and **Ms. N. Soumya** to help in writing and correcting English mistakes in this thesis.

I thank my batch mates **Mr. Kapil Kadam, Mr. Eranki L N Kiran, Mr. Sachin Kamble** and **Mrs. Madhuri Mavikurve** for providing me moral support and treating me like a younger brother. I thank all ET research scholars who encouraged me through constructive feedback throughout my research work.

I thank all the members of **IDP in Educational Technology, IIT Bombay,** who provided a friendly environment for research. My special thanks to the staff of **CDEEP** and **Educational technology department, IIT Bombay.**

I dedicate this thesis to my parents **Shri Ram Prakash Pal,** and **Smt. Geeta Pal** and my wife **Ms. Shalu Pal** who provide constant support at every tough stage of my thesis work.

I take privilege to thank to the people who helped me and supported me directly or indirectly throughout my academic career. I thank **Goddess Saraswati** for giving me the strength and capability for this long journey in the pursuit of knowledge.

Date:

IIT Bombay, India **Yogendra Pal**