

Blended Learning in Indian Colleges with Massively Empowered Classroom

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ABSTRACT

Students in the developing world are frequently cited as being among the most important beneficiaries of online education initiatives such as massive open online courses (MOOCs). While some predict that online classrooms will replace physical classrooms, our experience suggests that blending online and in-person instruction is more likely to succeed in developing regions. However, very little research has actually been done on the effects of online education or blended learning in these environments. In this paper we describe a blended learning initiative that combines videos from a large online course with peer-led sessions for undergraduate technical education in India. We performed a randomized controlled trial (RCT) that indicates our intervention was associated with a small but significant improvement in performance on a summative exam. We discuss the results of the RCT and an ethnographic study of the intervention to make recommendations for future, scalable blended learning initiatives for places such as India.

Author Keywords

Massive open online course; MOOC; India; Blended learning; RCT; Online education.

ACM Classification Keywords

K.3.1 Computers and Education

INTRODUCTION

A common claim made by supporters of online educational systems such as MOOCs is that they offer a revolutionary opportunity for global parity in the availability of education. The same high-quality education provided to those lucky enough to attend Stanford or MIT can be had by anyone with an internet connection, whether they live in Miami, Monrovia or Mumbai [16]. And while most MOOCs are still almost exclusively in English, more and more material is available in other languages: Khan Academy is working to translate much of its content to Spanish [11], Coursera and edX are working to extend the MOOCs to Chinese [9, 14] and the

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Queen Rania Foundation and edX recently announced *Edraak*, a partnership to provide MOOCs with Arabic content [15].

Despite the hype and fevered activity, very little research has explored the real and potential impact of online education in the developing world. In order to understand how advances in online education might benefit undergraduate education in India, we built and deployed Massively Empowered Classroom (MEC), an experimental system designed to support MOOC-like functionality and blended learning for Indian colleges. While many users of MOOC platforms are adult learners, we are particularly interested in how to engage existing students that are currently enrolled in traditional educational systems. Our pilot is focused on undergraduate technical education (specifically computer science). MEC currently offers four courses in partnership with more than ten large technical universities in India, serving educational content to more than 27,000 students.

In this paper we review the context of technical education in India and how online education is currently employed with a focus on existing students. With this as a backdrop, we describe a small scale randomized controlled trial (RCT) that we performed with a blended learning intervention based on MEC. We found that our blended learning intervention led to a small but significant improvement in learning as measured by a final exam. By combining this result with data from an ethnographic study of the intervention and the data collected from student satisfaction surveys, we make some recommendations for the effective use of blended learning interventions and directions for future research.

RELATED WORK

MOOCs and the developing world

While much has been made of the potential impact of MOOCs and online education initiatives for learning in developing regions such as Africa, Asia and Latin America [24, 37], there is little evidence so far of successes in these regions to match the hopeful claims. Most scholarly work to date on MOOCs in the Global South comprises either general overviews of MOOCs and the issues they may be expected to run into or solve [27, 11, 5] or program proposals tuned for the context of the Global South [38, 26].

Aside from our own work with MEC discussed in this paper, several other initiatives are now underway in India, Jordan, Rwanda, Francophone Africa, and several other countries [22]. For example, in May of 2014, IIT Bombay announced

the launch of three courses on the edX platform and there have been several government and private initiatives to introduce online teaching to Indian students [39]. As these programs are implemented, we hope to see some studies emerge describing how they fare.

Studies of blended learning

Online educational tools are used in a wide range of contexts for many different goals, but there is an increasing focus on blended learning, where online tools are combined with classroom activities and instruction to provide an overall improvement in educational outcomes [18, 4]. While descriptions and discussions around blended learning go back almost 40 years [e.g., 19, 40], the recent surge of activity surrounding MOOCs has provided a renewed interest in different ways to marry online learning with the classroom. For example, a proposal by Dr. Phatak from IIT Bombay advocates a blended learning model with MOOCs for technical colleges in India [38].

Along with this activity, there have been a variety of studies that have attempted to explore whether blended learning actually improves learning outcomes. One study that has received much attention was an experiment in San Jose State University where a course was supplemented with the MIT edX course on circuits [20]. They found that 91% of the students in the new blended learning format passed the course, compared with 59% of students in the traditional course offered the previous year, and that midterm and final exam scores were 10-12% higher than the previous year. These are very impressive results, though it should be noted that this intervention came at a substantial cost of time and effort by the teacher and students [23]. However, work by Lovett, Meyer & Thille showed large learning benefits with evidence that students were not working more outside of class [29].

A recent meta-analysis of 45 studies suggested that students in blended learning environments perform modestly better than those in face-to-face classes [31]. However, the authors note that most of these studies tend to confound additional learning time, instructional resources, and other course elements that may have contributed to the positive outcomes. We should note that some of these aspects seem less confounds than fundamental to the nature of blended learning pedagogy.

Other studies of blended learning have reported essentially no differences in outcomes [26, 5, 21]. Of particular note are two randomized controlled trials (RCTs) carried out by Ithaka S+R [5, 21]. In these studies, researchers conducted a number of trials with American universities to explore whether MOOCs could be hybridized with more traditional formats to improve outcomes and/or reduce costs for students enrolled in traditional institutions. They found that students taking courses in hybrid formats did as well or slightly better than students in traditional sections in terms of pass rates, exam scores and grades with less average class time from faculty.

There have also been efforts to understand the potential of blended learning for primary education in India. A project called Digital Study Hall has reached many students in rural schools, but has proven difficult to evaluate quantitatively [2]. A short-term study of multimedia teaching aids in peri-urban Bangalore found learning benefits in English but not in science [33].

However, to our knowledge there have not been any studies that evaluate the impact of blended learning in the context of higher education in developing regions such as India. While tertiary institutions often have better infrastructure than rural primary schools, they still have many constraints and are in urgent need of improved technical education. Considering the number of aspiring students in these regions, the potential benefit of new educational models is immense. In this paper we demonstrate some initial evidence suggesting that blended learning models can improve learning outcomes in engineering education in India.

We should note that our study of blended learning in the context of undergraduate engineering education in India is well-defined (as described below), and therefore repeatable. Although the possibility of blending online videos (such as the corpus created by the National Programme on Technology Enhanced Learning, NPTEL) with traditional curriculum delivery has been suggested [34], directives issued by the concerned educational agencies in this regard do not formulate clear implementation guidelines [31].

TECHNICAL EDUCATION IN INDIA

The context of technical education in India is very different from that in the Global North. In order to understand how online tools might be used to improve technical education in India, a brief summary of the scale, organization and constraints may be helpful. Engineering education in India is a huge enterprise and is very heterogeneous. In 2014, there were more than 3400 engineering institutes in India, teaching approximately 4 million students, and the rate of increase in enrollment is enormous: between 2009 and 2014, the intake of engineering colleges grew from 1.1 to 1.6 million students [1]. Outside of India, many people are familiar with elite institutes such as the Indian Institutes of Technology (IIT), National Institutes of Technology (NIT), Birla Institutes of Technology and Science (BITS), and others. However, these teach only a small fraction of all the engineering students in India (e.g., the total number of new seats for all 16 IITs in 2014 was ~10,000 [25]). The vast majority of engineering students enroll in a variety of other institutes across the country. Some of these are autonomous “deemed” or private universities, and a large proportion are colleges affiliated with state universities.

State universities are run by the governments of each of the states and territories of India and can be very large. For example, Visvesvaraya Technological University (VTU) in the state of Karnataka comprises 201 affiliated colleges, teaching more than 67,000 undergraduate students [43], and

Anna University in the state of Tamil Nadu comprises 520 affiliated colleges, with more than 120,000 engineering students [3]. All affiliated colleges in a university share a single, synced curriculum for every course. Textbooks, syllabus, and order of presentation of material are all prescribed by a central university authority, and for each course there is a single shared final examination taken by every student in the university.

A web of difficulties

These so-called “second-tier institutes” face a number of serious challenges. First, there is a critical shortage of qualified teachers. Every year, the number of students in engineering increases and there are not enough instructors to meet the demand. Some first-time teachers told us that they never intended to become teachers, but only did so because they could not find a job in industry and leave if they find an industry job. This leads to enormous inequality between institutions, with a few high-performing schools and a long tail of institutions with under-qualified staff. Because of high turnover and limited experience, teachers are given very little autonomy and must follow a rigid curriculum. In addition, they are given very little latitude in grading, with the majority of a student’s grade coming from standard final exams set by the university. In turn, colleges are often evaluated by their graduation rate, and thus have an incentive to evaluate students favorably. Therefore, most exams test rote knowledge instead of deeper understanding. High marks are given to students who memorize textbook responses rather than learn subject material, and the best students have little opportunity to distinguish themselves.

A lack of well-trained teachers and the limited relevance of classroom performance leads to uninspired students with little interest in subject mastery. In many instances, students spend their time optimizing for short term goals (e.g., memorizing questions from test banks) rather than learning the material. Naturally, this creates a feedback loop in which many teachers have little incentive to improve their skills or enhance the classroom experience for uninterested students who have no reason to pay attention.

As a result of these problems, industry has largely given up on many colleges’ ability to deliver quality education. Large companies such as Infosys and TCS hire students mostly on “raw intelligence” and then train them in custom computer science curriculum for up to 6 months before putting the new hires to work [41]. In our view, this represents an enormous waste of time and energy and leads to the question: Can this situation be improved through innovations in pedagogy such as blended learning and online education?

ONLINE EDUCATION IN INDIA

MOOCs and other initiatives in online education have taken center stage in much of the public and academic discourse surrounding pedagogy in the US, Canada and Europe. However, in India these efforts are still virtually unknown outside of an elite population. While supporters cite the thousands of students from India that enroll in MOOCs, these

numbers are still very small as a proportion of the student population of India (4 million undergraduates in engineering alone). Our research suggests that currently these resources are mostly used by adults for continuing education and a very small fraction of students who are driven to learn. Indeed, while students in elite institutions such as IITs are likely to be aware of these kinds of online resources, it seems that those who could benefit most from better quality teaching are the least aware of MOOCs.

Starting in 2012, our research group began a systematic exploration of how online education is currently used in India, what factors were holding it back, and how these tools might best be used to improve educational practice in undergraduate technical education. Much more detail is available in a separate report [10], but one finding stood out: on the whole, very few of the students or faculty we spoke with had ever heard of MOOCs (edX, Coursera, Khan Academy, etc.), and still fewer had actually participated in a course—and these were only top students at the better-resourced colleges. Many teachers were aware of NPTEL (a government-sponsored archive of online lectures by IIT professors) [42], though again, very few students or teachers regularly used this as a learning resource.

From these discussions we distilled four main reasons that we believe MOOCs and other online resources have had limited success in Indian undergraduate education so far:

- 1) The syllabi of online courses differ from university courses, and the level/speed of teaching is often too fast for students at regional colleges. In some ways this echoes the experience of other recent attempts to mix MOOCs with courses in other institutes [7]. A corollary of differing syllabi is that online materials are not directly relevant for exams. Students optimize virtually all their effort around cracking exams (see below). Even if online material relates directly to concepts taught in class, if it won’t directly improve exam scores then students aren’t interested. At the end of the day, it all comes down to employment and currently students do not feel that online content will improve their prospects.
- 2) Language and accent is a serious concern. While English is the official medium of instruction for undergraduate technical education in India, in practice many students from less affluent areas have only limited competency in English. Furthermore, many MOOC teachers have an American accent that can be particularly difficult for Indian students.
- 3) There remain serious network bandwidth constraints for most colleges and students. In every college we visited, video streaming was difficult, if not impossible. Outside of colleges, students see huge variability in bandwidth availability and cost. However, most online courses assume the constant availability of high-bandwidth connectivity to support video streaming and other interactive content.

- 4) Finally, but perhaps most significantly, these tools have not been embraced by college administrations. Teaching practice in India is extremely conservative (particularly at second-tier colleges) and teachers have little autonomy; students do what their teachers tell them to do, and teachers do precisely what their administration tells them to do (and little more). Unless a pedagogical technique such as using MOOCs for blended learning is dictated from the top, it is unlikely to be incorporated into any classrooms. Simply put, in the current university structure there are no real incentives for teachers and students to use MOOCs beyond intrinsic motivation, which is why it has had limited uptake.

These concerns motivated and informed our design of MEC.

Massively Empowered Classroom

We built Massively Empowered Classroom (MEC) to explore how online educational content and techniques in blended learning might be used for teaching computer science at state technical universities in India. Because online education is virtually unknown in these colleges, our research goals for MEC were broad and exploratory. However, beyond research, the primary goal was to provide students access to high-quality teaching for the curriculum that they were already enrolled in. We wanted to provide an environment in which students could learn everything they need to know for the subject they were studying.

To facilitate our exploration, we built our own platform. While at the time of this writing (late 2014) there are a few potential platforms that we might be able to use (e.g., [36]), when we began this investigation in 2012 these options were not available. Building our own platform gave us the flexibility to explore features and experiment with different ideas, as well as access to data and statistics about usage. MEC was designed to incorporate several features of MOOCs that we thought would be useful for this context, as well as a number of features that are not as common for MOOCs. Much more detail about the design and features of MEC is available elsewhere [10].

The first course we prepared was Design and Analysis of Algorithms (DAA), one of the core courses in Computer Science curricula. Anyone could sign up and take the course, but it was specifically designed for students affiliated with colleges in several partner universities. Content was created by a team of three to four teachers drawn from local research institutes and colleges. These teachers worked together to ensure that the material was of good quality and matched the syllabus of each university course. In addition, they made sure that the content was pitched to the level of the students and delivered in clear Indian English.

The DAA course provided for VTU (our first partner university) had over 45 videos, each 8-15 minutes long, covering eight units from the course syllabus. In the classroom, the university allocates 52 hours of teaching to cover this material. On MEC, there were also about 10

multiple-choice “quizzes”, roughly one per week (the number of videos varied somewhat for different university syllabi). Students were offered certificates at various levels to encourage participation. In the spring of 2014, we offered a “participation” certificate for scoring an aggregate of 50% or better on quizzes, a “completion” certificate for scoring 75% or better and a “distinction” certificate for passing a final exam administered in-person by the MEC team.

In addition to the standard online streaming of videos, the MEC platform attempts to manage bandwidth constraints by allowing students to download content for offline viewing on a PC and with an Android smartphone app.

A TRIAL OF PEER-LED BLENDED LEARNING

While the DAA course on MEC attempted to respond to several of the limitations with MOOCs identified above (e.g., matching syllabus, using local Indian teachers, and provision of offline and mobile viewing), MEC has largely been provided to students on a purely voluntary basis. We were also interested in seeing how MEC might be more tightly integrated into class as part of the basic course experience.

We have frequently observed that smart, motivated students take leadership roles in classes, often making up for absent or sub-par teachers. We wanted to see if a class based on MEC and led by a peer could be an effective way of improving learning for all students in a course, not just the students motivated enough to seek out MEC on their own.

To investigate this hypothesis, we performed a small RCT with several local engineering colleges. We hired a student in his 4th year of undergraduate studies in computer science from a local engineering college to facilitate weekly sessions in which videos from MEC were played to a group of students during regularly scheduled labs or recitations. In addition to playing videos, our class facilitator answered questions related to the video and discussed various practical applications for the material. At the end of the term, we conducted an exam to measure any potential differences in learning outcomes compared to a set of control colleges.

In addition to the exam, we collected both qualitative and quantitative data about the MEC sessions and the students’ perspectives on this approach.

METHODS

Selection of colleges for intervention

We restricted our experiment to colleges affiliated with Visvesvaraya Technological University (VTU). VTU comprises more than 200 technical colleges spread across Karnataka, with a high concentration of schools in the Bangalore area. All VTU colleges follow the same syllabus for each course, and students are evaluated with a single (identical) final exam across all colleges at the end of the term. By focusing on VTU, we hoped to reduce some of the variability across colleges due to curriculum and timing. To identify colleges for our study, we worked with the administration of VTU to obtain a list of anonymized exam scores of all students enrolled in the previous two years of

| College | 2013 | | 2014 |
|-------------|------------|---------------|------------|
| | Class Size | Exam (StdDev) | Class size |
| 1 Ctrl | 235 | 57.6 (15.3) | 233 |
| 1 Intvn | 298 | 57.6 (13.1) | 281 |
| 2 Ctrl | 205 | 55.1 (13.1) | 204 |
| 2 Intvn | 216 | 54.0 (13.1) | 207 |
| 3 Ctrl | 199 | 53.6 (12.3) | 217 |
| 3 Intvn | 187 | 53.9 (14.8) | 174 |
| 4 Ctrl | 292 | 53.2 (13.9) | 272 |
| 4 Intvn | 260 | 53.1 (16.2) | 234 |
| 5 Ctrl | 119 | 48.8 (13.1) | 109 |
| 5 Intvn | 124 | 50.5 (14.4) | 117 |
| Total Ctrl | 1050 | 54.1 (13.9) | 1035 |
| Total Intvn | 1085 | 54.4 (14.5) | 1013 |

Table 1. Class sizes and exam scores for control (Ctrl) and intervention (Intvn) colleges.

VTU’s Design and Analysis of Algorithms (DAA) course in all VTU colleges. From this list, we selected five pairs of colleges from the Bangalore area where each pair was roughly matched on class size and exam scores from previous years (a loose proxy for quality of students and instruction). The five pairs of colleges ranged from more exclusive schools (known for competitive enrollment and higher exam scores) to less competitive colleges with lower exam scores. Other eligibility criteria for colleges included:

- More than 100 students enrolled in DAA in 2013
- Fewer than 10 students enrolled in MEC in 2013
- Not an outlying high or low performer

From each pair, we randomly assigned one college to the intervention and the other as a control. See Table 1 for population and exam details for each college pair.

We then contacted the administrators and teachers for each intervention college to seek permission to work with their DAA classes for the spring term of 2014. We arranged for our research assistant to visit each college once a week, usually during lab or recitation, to conduct sessions featuring videos from the MEC DAA course. As an incentive and token of thanks, each college was promised a plaque indicating their participation with our organization in the initiative.

The intervention

At the beginning of the term, our peer mediator (PM) visited each intervention college and encouraged all the students enrolled in DAA that term to create an account on MEC. At this first meeting, he described how the system worked (how to login, watch videos, use the forum, etc.), and played the introductory video to the group. Then for the next seven weeks, the PM visited each college for a session with MEC, for a total of 8 sessions. The PM was explicitly instructed not to go beyond the material shown in videos and was very careful to limit his discussion only to those concepts he played in each session. In three colleges, students from classes in Information Science and Engineering (ISE) and Computer Science and Engineering (CSE) participated. Because of the large numbers of students in these colleges, sessions were divided up into multiple sections in a day (see

Table 2 for details). Note that in some colleges we were only able to hold sessions for a subset of students. Due to a variety of scheduling conflicts and administrative issues, we were only able to hold 3 sessions for one college (#5) and had to drop them from the intervention. On average, the PM taught approximately 22 sections per week for about 180 total sections.

Note that for both intervention and control colleges, students spent the same total amount of time in class. At the intervention colleges, students spent an hour each week with the PM viewing and talking about MEC videos, while in control colleges students spent this time in their regularly scheduled labs/recitations.

It is also useful to note that while the PM was certainly a very good student who was passionate about CS, he did not have a particular interest in algorithms and was not considered a “topper” in his own DAA class when he took it. He estimates he was in the top 50% of his DAA class, though he was particularly good at implementation vs. theory. While the PM had no experience teaching, he did have some experience speaking to student groups as an evangelist for OpenStack.

Learning outcomes—terminal review exam

At the end of the term, we conducted a final exam for students in both intervention and matched control colleges. The exam was described to students as a “review exam” covering material from the full range of topics covered by the VTU syllabus for DAA. At the end of the exam, a member of our team went over each question and walked through the solution. The exam was designed by two of the authors; one was a professor at a local college and familiar with the VTU syllabus. The test comprised ten multiple-choice questions (the last two were connected and graded as a two-point unit), for a total maximum score of 10. A time limit of 40 minutes was set for the exam. The exam can be viewed at <http://research.microsoft.com/~cutrell/DAAex.pdf>

The teachers and administrators at these colleges were keen to host our review session, and made attendance mandatory for all students enrolled in DAA. At each college we recognized the top five scorers on our exam and gave them some small awards (t-shirts and gift cards).

As noted above, we were unable to conduct regular sessions with college #5 and had to drop it from the experiment. Also, due to scheduling problems we were unable to perform the exam for either college #4 or their control. Ultimately, a total of six colleges—intervention colleges #1-3 and their controls

| Intervention college | Sections | | Sessions Conducted (per section) |
|----------------------|----------|-----|----------------------------------|
| | CSE | ISE | |
| 1 | 5 | 3 | 8 |
| 2 | 3 | 1 | 8 |
| 3 | 4 | 2 | 8 |
| 4 | 2 | - | 8 |
| 5* | 2 | - | 3 |

Table 2. Sessions conducted for each intervention college. Note that we were unable to complete the intervention for college 5.

– took the exam.

Field study and satisfaction surveys

To understand how students experienced our intervention, we conducted an ethnographic study of some of the MEC sessions. An ethnographer accompanied the facilitator to conduct observations of the sessions and in situ interviews with students and teachers. The ethnographer attended 78 sessions, visiting all five intervention colleges at least twice (for a total of around 16 days of observation). In the first session for each section the ethnographer introduced herself and got permission to record and take photographs. After that she typically sat at the back of the class observing and taking notes. Data was collected through detailed field notes, audio recordings, short video recordings and photographs. The analytic approach to the material was broadly ethnomethodological [17], an approach which reveals how social order is achieved in settings such as offices [35] and schools [29].

Finally, in the last of the MEC sessions, the PM conducted a student satisfaction survey consisting of a mixture of ratings (using a 5 point Likert scale) and free text response to establish how the students felt about various aspects of the MEC sessions, from their opinions about the facilitator to whether the sessions helped them understand the practical applications of algorithms.

RESULTS

MEC usage beyond the classroom

We examined the usage logs from MEC to look at how students used MEC individually outside of class. Overall, MEC was not extensively used by many students outside of the classroom sessions. While 308 students in intervention colleges (about 30% of those enrolled in DAA) watched at least part of one video, 206 of those students never opened more than three videos. The median total time of video watched for these 308 students was just 10 minutes, and only 50 students watched more than an hour of total video. This was moderately disappointing, as we hoped that the classroom sessions would increase independent usage outside of class much more than it did.

Of course, individual use of MEC in the control colleges was even less: only 39 students watched at least one video (about 4% of students enrolled in DAA), but about the same proportion (66%) never opened more than three videos. We expected the number of users in control colleges to be less since they would have only heard about MEC through word-of-mouth or general announcements across VTU (versus the active promotion in intervention colleges).

Observations of blended learning in practice

To put the results of the RCT in context it is useful to understand some details about what went on in the intervention and how students responded. Overall, MEC sessions were fairly consistent; the PM would typically repeat the same topic across colleges and sections, and the same topic looked similar in each session. Variations typically stemmed from the engagement and academic level

of students (e.g., responsiveness to questions, ability to arrive at the right answer). For the purposes of this paper it suffices to give a general overview of the sorts of activities the PM and the class engaged in.

Classes were highly interactive from the beginning. The PM would start off by asking the group what they had covered already in class in relation to the day's topic. For example, "What are the different algorithms for sorting?" or "What have you learned about greedy algorithms?" Questions were answered by the group or individually and served to make the content relevant to the students' learning, to engage them and to give the PM an idea of level of learning. The PM would then play that day's MEC video. On most occasions, he would play a few minutes of video (1-2 minutes) and then pause to discuss. In a very few observed sessions he played longer segments of video (e.g., 7-10 minutes); although students initially attended to the video, the visible attention level in the classes rapidly dropped. To address this the PM interspersed video and interaction, pausing the video to do several activities:

- 1) *Soliciting a solution to a problem posed in a video before the answer is revealed.* The PM would ask the class to solve the problem – typically getting some class members to come to the front and write the solution on the board before continuing the video. For the most part this was an engaging and well-received strategy (confirmed by interviews with students). However it was a notable failure in at least two cases, where the PM failed to get any engagement on one particular problem, seemingly because it was too hard for the given section.
- 2) *Priming the video by asking about concepts before they are introduced.* At one point the PM paused the video, wrote 'encryption' on the board, and asked "what does this term mean?" The resulting interaction was a set of student responses which he probed further. When restarting the video, it would typically repeat some of what had just been covered before moving on.
- 3) *Pausing the video to emphasize a point, e.g., making it relevant to the student's experience.*

These interludes between the video clips typically lasted between a few seconds and several minutes. While we cannot say that the PM did not discuss anything at all that was not on the video, by and large he did not add content. Rather he made the session more interactive, encouraging group responses and competition for solving problems and pushing quieter members of the class to answer questions. In this way a 10-15 minute video could occupy an hour class and sometimes he did not even finish playing the video. At the end the PM wrapped up by summarizing what they had learned and often giving them a small task they could go and try themselves.

One challenge to the typical pattern occurred when there were power cuts. In about four of the observed classes the PM could not play video for the entire section. Nonetheless,

these classes followed the same topics as the other sessions, as by that stage the PM seemed to know the material by rote.

Although purely subjective on this matter¹, the impression of the ethnographer was that classes combining video and facilitation resulted in the best engagement.

Student feedback

In the short interviews with students conducted just after the sessions or in the college corridors, students said that they appreciated the interactivity of the classroom sessions and learning about the practical applications of algorithms. They compared it favorably to the standard teaching they received, which they described as largely involving the teacher writing on the board while they took notes. Some even said that labs took a similar shape (the teacher wrote the code on the board and they typed it into the computer).

Student satisfaction forms were distributed to the students at four colleges (excluding college 5) during the final session and 326 were returned completed. A majority (60%) rated the overall MEC sessions good or excellent (4 and 5 on the scale), 7% poor or fair (1 and 2 on the scale) and 32% satisfactory. Most (69%) also agreed (or strongly agreed) that the sessions “improved my understanding of algorithms”, with only 5% disagreeing and 27% neutral. We also asked the students to rate the “outreach MEC lecturer” (the PM) and the “videos played in class” to see if one appeared more influential than the other in the students perception of MEC classes. About 63% rated the PM as good/excellent, whereas 50% rated the videos as good/excellent. Students’ ratings of the PM were significantly higher than MEC videos, Wald $\chi^2(1) = 9.21, p < 0.002$.

Students were able to provide free text comments for each question and a majority of students did so. Around a third of the comments about the overall MEC sessions praised the sessions for being interactive, interesting, practical or just plain different from their normal classes. This backs up the interviews, indicating that students appreciate this different pedagogy to the usual “chalk and talk.” Almost half the comments mentioned personal factors about the PM, mentioning things such as communication skills, accent, enthusiasm and teaching style; about two-thirds were positive, and the rest were negative. In terms of the videos, 40% did not find them interactive or practical enough, however nearly 80% of students who commented on their clarity of explanation and depth were positive. Finally, 11% noted that the ‘playback quality’ in class made it hard to engage (due to sound, screen size, etc.). In some sessions, videos were played on a desktop computer monitor for 20 students, so this is not surprising.

Review exam

A total of 935 students from six colleges participated in our

¹ While it is relatively easy to judge visible engagement on a minute by minute basis, it is another matter to judge engagement over a whole class period.

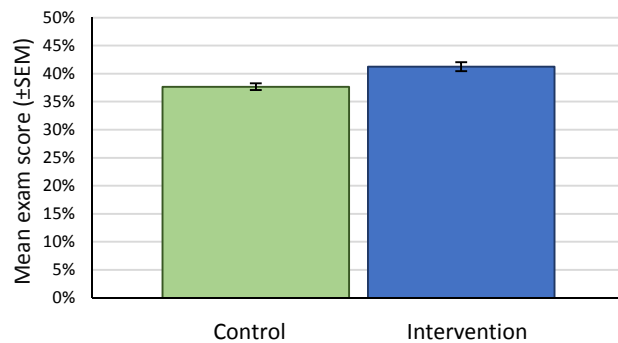


Figure 1. Mean scores on cumulative review exam for control and intervention colleges.

review exam. In five of the six colleges, students from both CSE and ISE departments participated (in one college the ISE students were unable to attend). According to school records, there were 1316 students enrolled in DAA at these six colleges, so ~70% of enrolled students participated. Note, however, that some enrolled students were in neither CSE nor ISE departments, and are not included in our analysis.

Our hypothesis was that the MEC intervention would improve performance on tests of understanding basic concepts in DAA. In addition we were curious whether the intervention might have a differential impact on ISE students. CSE departments are typically more competitive than ISE, and ISE students usually do not do as well as those in CSE. As our intervention was a substantial departure from typical Indian pedagogy, we wondered if there would be any difference in how students performed.

We performed our statistical analysis on log-transformed data to overcome the mildly skewed distributions of exam scores and to normalize variances between conditions. However, we performed a 2 (Intervention) x 2 (Department) between-subjects ANOVA on log-transformed exam scores². We found a small but significant effect for Intervention, $F(1,930) = 14.54, p < 0.01, \eta^2 = 0.02$, with our intervention colleges scoring on average about 3.6 percentage points better than the controls (see Figure 1). There was a borderline effect for Department, $F(1,930) = 3.37, p < 0.07$, where CSE students scored about 1.9 percentage points better than ISE overall. Finally, there was also a small borderline interaction effect between Intervention and Department, $F(1,930) = 3.46, p < 0.06$. To test for possible moderation effects of Department on Intervention, follow-up simple effects show that there was a significant effect for Department in the Control group, $F(1,930) = 8.15, p < 0.004, \eta^2 = 0.01$, with CSE students scoring on average 3.5 percentage points better than ISE in control colleges and only

² A potentially more rigorous analysis is to regress scores on our exam against the previous year’s final exam scores. This actually led to a slightly larger effect, as intervention schools performed worse than control schools in the prior year (in the three matched pairs that took our exam). However, for simplicity of presentation, we chose to

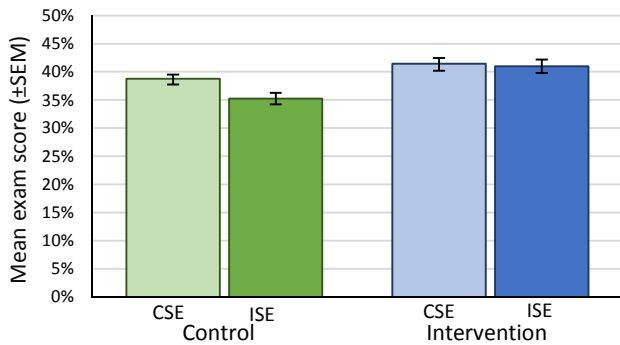


Figure 2. Mean scores on cumulative review exam for control and intervention colleges broken down by department.

0.4 percentage points better in intervention colleges (see Figure 2). That is, ISE students performed almost as well as CSE students in intervention colleges.

A detailed exploration of performance on each question indicated that two questions seemed to account for most of the difference in exam scores between control and intervention colleges. Figure 3 plots the difference between the percentage of intervention and control students that were correct for each question. Note that while most questions are close to zero, questions one and five stand out: more students in the intervention answered Q1 and Q5 correctly, by 17 percentage points and 9 percentage points, respectively.

We performed a chi-square test of independence between intervention and performance on the first eight questions. To control for multiple comparisons, a Bonferroni correction was used to set $\alpha = 0.006$. Only questions one and five were significant. For Q1, $\chi^2(1, N=934) = 24.7, p < 0.001, \phi = 0.16$, and for Q5, $\chi^2(1, N=934) = 9.5, p < 0.002, \phi = 0.10$.

While we are not certain why the two groups performed differently on these two questions, we speculate that it may be because these were the only two questions on the exam that required students to work through a piece of pseudo-code. We discuss this in more detail below.

DISCUSSION

To our knowledge, this is the first study to show improved

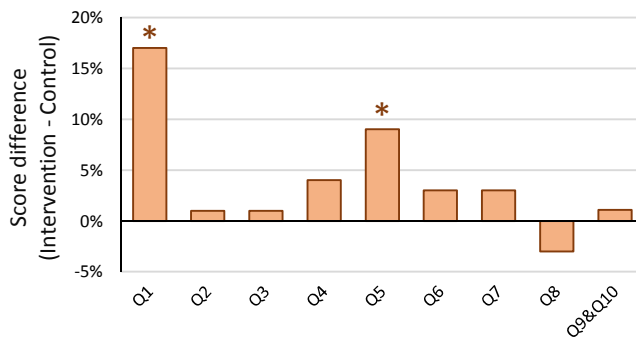


Figure 3. Score difference (% correct) between intervention and control for each exam question. Differences for Q1 and Q5 are significant at $p < 0.006$.

learning outcomes for a blended learning intervention in India. We found that a relatively small number of group sessions with video content led by a student facilitator resulted in an overall improvement in a cumulative exam at the end of the course relative to a control. Even though the size of the effect is relatively small (an average of about 3.6 percentage points improvement), it is statistically reliable.

While this difference in exam scores is very encouraging, there are a number of factors in our intervention that may have contributed to this effect. Though one might argue that many are integral to the blended learning initiative itself, it is worth pointing them out here. Several of these factors are similar to the “confounds” noted in the meta-analysis by Means, et al. [32]. While hardly exhaustive, we discuss some of the factors that one might argue contributed to the improvement in learning performance:

- 1) *Novel pedagogy.* Unlike the standard “chalk and talk” teaching style typical of Indian classroom instruction (where the teacher writes on the board and students copy into their books), MEC sessions with the PM were very interactive. Video watching was frequently interspersed (typically every few minutes) with classroom interaction—completing problems, answering questions and emphasizing points. This served to keep the class engaged, except where problems or topics seemed too difficult for the class level. By making these sessions highly interactive, the PM capitalized on the full classroom experience of blended learning, including elements of competition, peer learning, humor and so on—all of which served to make the classroom experience more engaging. While more investigation is needed it seems likely that this is one of the most important factors and is consistent with prior work [29].
- 2) *Novelty.* Rather than the standard recitations and labs that students were used to, MEC sessions with the PM were a break in the routine. It is possible that this basic novelty was sufficient to cause students to pay a bit more attention than they otherwise would have. The difference between these sessions and normal lectures was a positive theme reported in the satisfaction survey.
- 3) *Quality video material.* The MEC videos were simply effective at communicating the content to students.
- 4) *Personality of facilitator.* The PM is a very outgoing and energetic person. His dynamism may have been enough to cause students to pay attention when they otherwise would have been drifting.
- 5) *Peer effect.* Instead of their normal professor, a peer (fellow student) discussed the material with them.
- 6) *Company branding and certification.* Our organization is very well known and an association with the company is likely to be very motivating for students.
- 7) *Independent use of MEC.* We actively evangelized the use of MEC outside of class and more students in the intervention colleges did use MEC on their own than in control colleges. It’s possible that this use by the 50 or so

students in the intervention colleges is what carried the difference in the exam, though we think this is unlikely.

- 8) *Use of code in teaching.* In most colleges we partnered with, the use of code (or pseudo-code) is rarely if ever used when teaching DAA. In contrast, this is fairly common in MEC videos. The performance boost associated with the two questions on our exam containing code fragments suggests that this might be important.

One fascinating observation in our study was the potential differential effect of the intervention for ISE students. We are not certain why ISE students in the intervention colleges performed so much better than those in the control colleges. Since the exam scores that we received from VTU in Table 1 did not separate out ISE and CSE students, we were not able to explicitly control for the strength of departments. It is possible that the ISE departments in the interventions schools were simply stronger than those in the controls. However, if ISE students in intervention colleges were similar to those in the controls, it is possible that the MEC sessions were particularly effective for the weaker students in ISE. This finding would be consistent with observations by Cima and Ghadiri, et al. [8, 20] that online learning is particularly beneficial for lower performers. While we would like to believe this is true, we cannot conclude from this data why we saw this.

A few notes about peer-led blended learning

While any (or all) of the factors above may have contributed to the learning gains, it seems likely that the novel pedagogy played a very important role in at least keeping students engaged. In particular, the combination of the videos and the student facilitator seemed to be important. While the content of the videos was generally good, it is unlikely to be the main factor. The videos certainly didn't get universal approval, and there were mixed opinions around how interesting they were. Furthermore, playing 4 or 5 minutes of video resulted in a noticeable drop in attention. However, the PM organized his sessions entirely around the videos; while he was indeed an enthusiastic and passionate person with a strong interest in practical aspects of computing he was by no means an expert teacher. For example, he had difficulty tailoring his explanations to the different levels of understanding found in various colleges and sessions, even when classes completely failed to solve set problems. This was the case despite the video content including easier examples which might have been used with these students.

It seems likely that the success of the blended learning initiative comes not so much by forcing students to consume video content but by combining video content with engaging classroom interaction. Some interesting points arise from this observation: 1) Videos which *enable classroom activities*, such as problem solving, seem to be particularly appropriate for blended learning scenarios. This suggests that online lectures intended for blended learning might be specifically designed to incorporate these kinds of strategies. 2) *One size does not fit all*, even when the content has been designed for

the relevant syllabus. How could online courses help to guide less experienced facilitators to adapt their sessions to the level of the class? It would be interesting to consider how blended learning material might be designed to support this as in [29]. 3) *Blended learning doesn't make teaching easy.* While it seems that an experienced teacher is not needed to run a successful blended learning class, it is still no easy thing to do. Despite his efforts to make algorithms practical, the PM often had to work extremely hard to stir up any sort of engagement or interest. Even as we design materials to maximize the potential of non-experts and peers as teachers, these teachers will still need to have some grounding in the subject they teach as well as passion and enthusiasm; it seems unlikely that technology will substitute for these human factors any time soon.

CONCLUSION

We found that offering a peer-led blended learning session once a week for eight weeks in the place of a normal recitation or lab led to a small but significant improvement in learning outcomes as measured in an RCT in Indian technical colleges. A concurrent ethnographic study of the intervention suggests that much of the success of the intervention had to do with the way in which the combination of video and peer facilitation drove student engagement. We believe that interventions such as this could help to ease some of the serious constraints in higher education in India and other developing regions where the demand for education far outstrips the supply of trained teachers. Our research suggests that an interactive combination of video teaching by local professors and an energetic peer facilitator can be effective in "second-tier" technical colleges.

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