# Impact of Multi-media Tutorials in a Computer Science Laboratory Course – An Empirical Study

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**Abstract:** Higher education institutes of North America, Europe and far-east Asia have been leveraging the advances in ICT for quite some time. However, research based knowledge on the use of ICT in the higher education institutes of central and south-east Asia is still not readily available. The study presented in this paper explores a variant of teaching and learning laboratory sessions using multi-media in an Indian engineering institute. Multi-media tutorials were used to self-teach Linux operating system to the second and third year students of IT and non-IT branches of engineering degree program. The paper contains the description of the sessions conducted, empirical data, results and impact on students' learning. The results reveal that multi-media tutorials can be highly useful and beneficial in the early years of engineering to create the solid footing needed for further studies. They act as multipliers for capacity building efforts of students and encourage self-learning.

**Keywords**: Multi-media learning, laboratory courses, video-tutorials, blended-learning

## 1    Introduction

Information and Communication Technology (ICT) is making rapid progress among higher education technological institutes of India with IITs leading the way. However, there is still a lot of ground to cover as more multi-media or online lessons are added to the face-to-face, traditional blackboard system in the classroom. There is recognition of the need to train teachers in ICT, but many of the training activities to date have been one-off crash courses which focus on computer literacy and do not enable teachers to integrate ICT in their day-to-day teaching activities and master the use of ICT as an effective tool to improve teaching and learning.

Blended learning approaches using multi-media become especially important in a country like India, where prevalent system of education is largely rote based.  By the time students come to engineering courses, they are saturated (Bhagat, 2012). This is the culmination of many years of exam-driven curriculum and focusing on competitive tests. They are ready to welcome non-traditional methods of teaching and learning. The sheer number of students taking engineering courses is also very high compared to other developed and developing nations of the world (UNESCO, 2006). The result is that with an average class strength of 50 to 60 students, everyone is forced to learn the same thing on the same day, in the same class, at the same speed, even though everyone has different cognitive abilities. The problem of student diversity, due to different cognitive abilities is, of course, omnipresent in engineering degree programs (Mok, 2012). There is a need to make learning more engaging and relevant for students. According to Popova (2012), even Isaac Asimov believed in the power of curiosity-driven, self-directed learning and the need to implement creativity in education from the onset.

## 2    Benefits and Drawbacks of Multi-media Learning

The biggest benefit of multi-media learning is that the time, place and dynamics of learning are adjusted to the individual needs.
It can provide a good introduction to complex topics. Using animations and videos, the workings can be explained easily.
Multi-media also encourages participation and engages students in real-time learning.
It can help novice students improve their proficiency and scores, and proficient students can continually remain engaged with new challenges and content.
Learning through multi-media promotes independent learning.

However, multi-media learning can have demerits -

Multi-media lessons require special hardware and software configurations making it difficult to adapt.
There are limited structural guidelines available as multi-media learning is a relatively new field.

The price of upgraded technology, as well as costs of hardware and software, can be substantial.

Multi-media learning caters to learner autonomy and flexibility, but can it sustain the stimulation and self regulation of learners? Students must be supported in making connections between what they have learned and how to apply that learning (Ellis, Goodyear, O'Hara & Prosser, 2007). Multi-media lessons without an instructor can fail to achieve this connection.

With these known benefits and drawbacks of multi-media learning in mind, the study undertaken investigates the usefulness of multi-media tutorials on three different cohorts of engineering student population from one engineering institution. The rest of the paper discusses recent related works in other engineering institutes around the world, context and methodology of the study undertaken, empirical results and analysis. The paper concludes by drawing attention to pedagogical implications of multi-media tools for mainstream educators.

## 3    Literature review

Many studies have shown (Bentley et al., 2012; Harrington et al., 2009; Folley, 2010) that both academicians and students see value in technology enhanced lecturing. Multimedia tools of different learning designs have been used as self directed learning resources in higher education institutes around the world. The same approach can be exploited in a laboratory environment as well. Simoni (2011) used tablet PCs with interactive software to teach IC design and illustrated through numerous examples how technology can facilitate active participation of students. Observations and comparisons between the assessment data suggested an improvement of retention and understanding of the course content for students.
Multi-media content with video clips, power –point presentations and web resources were used in a learning management system to teach Microcomputer Applications laboratory in Thailand (Buraphadeja & Kumnuanta, 2011).

Trenas (2011) et al. applied Moodle module *CTPracticals* to teach practical aspects of Computer Organization. The automatic verification engine in the module was used effectively to process the VHDL designs submitted by students in real time. The authors went on to propose that this application can be extended to include other programming languages.

Advanced School of electrical and Computer Engineering, VISER in Belgrade, Serbia (Djenic et al., 2011) experimented successfully with an advanced variant of teaching programming fundamentals.  They used blended approach – classroom teaching with multi-media material and lessons delivered over internet.

In an advanced experiment at University of Madrid (Munoz-Oreganaro et al., 2012), learning pills were sent on mobile devices to teach students configuration of network services in Linux environment. The contextualized learning pills were successful in improving the ratio of student class attendance, student performance and student motivational patterns. Future work being planned includes multi-media (video) pills for mobile devices that summarize course concepts.

Lai (2011) on the other hand argues that impact of digital technologies in terms of improving the learning experiences of the students, is rather limited. However, using technology as a participatory communicative tool to support collaboration and co-construction of knowledge can improve the quality of the learning experiences.

## 4    Context and Methodology of the Study

The goal of laboratory coursework is to establish the connection between the theoretical and conceptual learning that happens in the classroom and the practical applications of the same knowledge. As Verginis (2011) et al. point out, laboratory exercises provide the cognitive hooks that help students in associating the newly acquired knowledge with hands-on engineering experience.

However, the effectiveness of the laboratory sessions has been a subject of debate due to various factors. Loss of concurrency between the theory and lab sessions can burden and deter the synchronous nature of the teaching-learning process. Then there are other limiting factors like time constraints, lack of

resources (compared to developed nations), large number of students and their varied intellectual capabilities.

A research study was initiated to investigate if the students' receptiveness and performance is enhanced by multi-media tutorials, given the above scenario of applied laboratory lessons. The context used was a computer science laboratory course on Linux Operating System.  The multi-media material was provided by the Spoken Tutorial team at Indian Institute of Technology, Bombay (IITB) (under the "Talk to a Teacher" project of the National Mission on Education through ICT launched by Ministry of Human Resources and Development, Government of India). The teaching content was a mix of videos, presentations, screen-shots, examples of various command and utilities being executed as well as assignments. Each tutorial was contained to 15 minutes in order to ensure the attention of the learner.

The multi-media lessons introduced Linux desktop and environment, basic commands, file system, file attributes, redirection and pipes, processes and general purpose utilities. Three sessions were conducted during the winter semester of academic year 2011-12 for this study.

## 4.1    Process Outline

Multi-media tutorials in Linux were offered to the students of second and third years in engineering as an additional self-study course.  The course was voluntary for students and there were no lectures for it locally. A total of 134 students registered and they were divided into three groups with differing educational backgrounds.

Table 1 summarizes the details of each group. The first two groups were created for the students of IT disciplines – computer science or information science, who are familiar with the concepts of operating systems. The third group was created to widen student participation across other engineering disciplines like Electronics, Medical Electronics, Tele-communications and Mechanical Engineering. This is the Non-IT group in table 1, where high-performing students were selected based on their university exam results as well as their desire to learn something new. The idea was to understand independent learning through multi-media tutorials for a group which was not exposed previously to the theoretical concepts of operating systems.

**Table 1:** Formation of groups

| Group | Number of Students | Background |
|---|---|---|
| A | 42 | IT – 2nd year |
| B | 62 | IT – 3rd year |
| C | 30 | Non-IT 3$^{rd}$ year |

A brief orientation session was given to the students to explain the process and also to judge their comfort level with the self-study multi-media tutorials. Small demonstration was also conducted to show them learning by doing. Both the tutorial and the target software would be open on the desktop (see Appendix A). They listen to a command in the tutorial, pause, and practice on the target software. If the command works and they want to, they can move on to the next one or rewind and listen again. Students were told to complete the tutorials at their own pace. Figure 1 encapsulates the steps involved in this process.
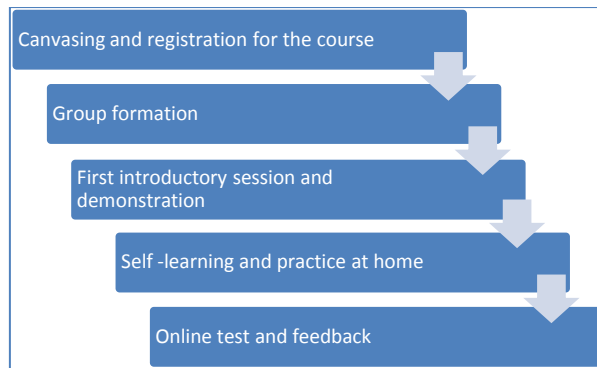
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**Figure 1:** Process outline

Answers were sought for the following research questions during this exercise.
Are the students willing to participate in such co-curricular activities which are not mandated by the university to fulfill their degree requirements?
Do the multi-media tutorials adequately support and encourage the learning process?
How do the self study multi-media tutorials affect students' performance in exams?
What is the feedback from students on the effectiveness of multi-media learning?

## 4.2 Evaluation Criteria

Online tests were conducted by the Spoken Tutorial team at IITB after about 20 days of self-learning time. The multiple choice questions in the test were selected keeping in mind the CAMP (Conceptual, Analytical, Memory based and Practice based) model of evaluation. This ensured that students were tested on all aspects of learning – understanding of concepts, ability to analyze and solve a given problem as well as remembering Linux commands or order of events. Multiple test versions were generated to avoid possible copying/leaking of questions. To boost the motivation, certificates were promised and given to all students who passed the test with more than 40% marks.

## 5 Results and Analysis

Figure 2 shows methods of qualitative and quantitative data collections employed during this study. The aim was to link the data gathered and patterns emerging from it to propose the findings (Yin, 1994).
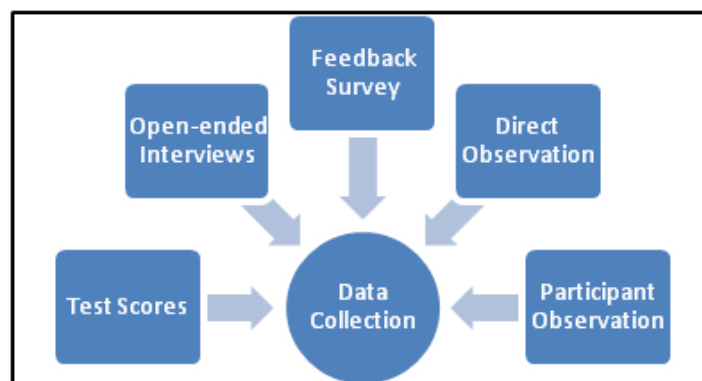


**Figure 2:** Data collection methods used

The participants were asked to observe their own study patterns and times spent while using multi-media tutorials. Apart from the online tests, a brief feedback survey was also conducted. Participants were asked to email their feedback to correlate the responses to their test scores. The participants were assured of the confidentiality of their responses.

All the 2nd year (Group A) and 3rd year (Group B) students of the Information Science department were given a choice of taking this additional self-study course. Figure 3 shows the participation of students.
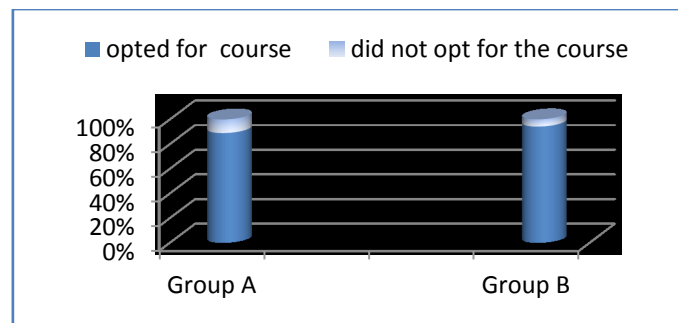
**Figure 3:** Breakdown of participation in the multi-media course

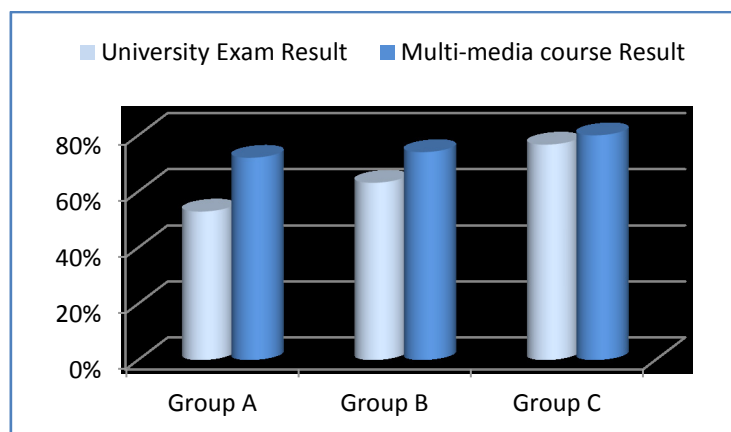Figure 4 shows average test scores for the three cohorts of students outlined in table 1.



**Figure 4:** Difference in test scores

Upon reviewing the results of quantitative tests and open ended interviews, following key observations are supported regarding effectiveness of multi-media learning in traditional teaching environments.

Multi-media lessons are well-received and preferred over their traditional counterpart i.e. classroom teaching by students.

This is in keeping with the flexibility, interactivity and novelty factors offered by the multi-media tutorials. Folley (2010) has concluded that perceived importance of classroom teaching from students' point of view is reducing. They prefer alternative teaching methods, expect certain level of technology and are comfortable with it. Figure 3 shows that though optional, the participation levels exceeded 90% of the student population. This is an improvement over the logged classroom attendance of about 75% in the same institution. As more multi-media content starts getting blended with the traditional teaching, there may be an optimum point beyond which the students' willingness to participate may taper off.

Multi-media tutorials enhance the teaching-learning process and there is an improvement in results.

The average test results showed marked improvements for all groups (see Table 2). The standard deviation in results went down and was consistent across all three groups.

High performers are much more receptive to technology when used effectively.

Group C was formed with the students of other disciplines who were not exposed to operating systems classes previously. The assessment data for this group shows that this group had less room for improvement to begin with, however 7% increase in result was noted. Very small amount of variance observed for this group is also consistent with their results. The verbal feedback from this group indicated

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that they had no difficulty learning the content and excelling in the test that followed, despite no prior exposure to the basics of operating systems.

**Table 2:** Overview and comparison of results

| Group | University Exam | | | Multi-Media Course | | | Differen-ce in results |
| | Mean Result | Min-Max (count) | Std. Dev | Mean Result | Min-Max (count) | Std. Dev | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| A | 54.80% | 25.00%-71.22% (42) | 10.54% | 71.69% | 60.65%-91.80% (42) | 7.23% | 16.89% |
| B | 62.28% | 34.08%-81.90% (62) | 11.94% | 73.43% | 59.01%-85.24% (62) | 7.64% | 11.15% |
| C | 73.53% | 56.78%-83.54% (30) | 6.62% | 80.69% | 62.29%-88.52% (30) | 7.30% | 7.16% |

Multi-media tutorials are especially helpful during the formative years of engineering when students are learning critical, core courses.

The result for Group A is an interesting discovery. Even though the mean university exam result for this group of second year students is very low, they scored as well as other groups in the self study multi-media course. Analyzing this further reveals that there is a jump in required proficiency from high school to college. Students struggle to keep up with vast syllabi, engineering mathematics and demanding laboratory sessions. Very soon they start losing interest and a few even drop out. Multi-media teaching can help alleviate some of these issues in early college years, keeping the interest alive and participation level high.

To examine other patterns, individual university exam results were merged into four cohorts. The results and statistical evaluations for this are summarized in Table 3.

**Table 3:** Analysis of results

| Cohort Number | Description | Result Univ. Exam | Result multi-media course | Difference | Min | Max | Standard Deviation |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 70% and above | 74.34% | 80.32% | 5.98 | -4.99 | 17.30 | 0.047690 |
| 2 | 60 to 69% | 64.90% | 73.20% | 8.30 | -2.20 | 23.00 | 0.074103 |
| 3 | 51 to 59% | 55.45% | 69.76% | 14.31 | 0.28 | 30.16 | 0.070065 |
| 4 | 50% and below | 43.22% | 70.22% | 27.00 | 10.65 | 46.24 | 0.100342 |

Advantages of multi-media tutorials are higher for the students who underperform in traditional system.

Analysis in Table 3 clearly shows that students who score poorly in university exams have done significantly better in the self study multi-media course exams. In some cases the difference in result between the two was as high as 45%. A striking discovery was the fact that 30% of the students from this group ended up in the top 10% performers of all groups. Upon interviewing it was discovered that majority of the students in this group are either visual learners or hands-on learners who spent significant amount of time learning and practicing and benefitted highly from multi-media tutorials.

A negative MIN number was observed for 1.5% of the students who scored less in the Linux multi-media course test. Direct observations during introductory sessions showed that students were able to master the Linux commands easily and enjoyed trying out different options in CLI window. Open-ended interviews were conducted and a small survey was taken over email after the tests to understand two major factors.

How many hours of self-study and practice did the students put in before the tests?
What motivated them to do this?

Students spoke favorably about active role, comprehensibility, graphic displays and individualized learning. It was very clear from the response of the participants that multi-media tutorials were interest-driven learning for them and with interest came engagement. They definitely put in more time studying and practicing for this course than they would for any other comparable laboratory or class assignment.

### 5.1 Limitations

Several limitations related to this study are worth noting. Since students of Non-IT disciplines of engineering were also involved in the study, it was not possible to compare traditional university exam and multi-media course results for the exact same subject. Hence, overall university exam results were used to maintain consistency across all groups.

Multi-media tutorials used for the study were prepared by the Spoken Tutorial Project Team at IIT-Bombay. The course content and quality of the tutorials are out of context of this study and were never questioned or considered a factor in the results.

## 6 Conclusion

Thomas & Brown (2011) talk about two radically different learning environments. First is the traditional classroom which is overly structured. Second environment is completely unbounded and unlimited - online learning. They contend that the second type of environment does not necessarily lead to improved learning. The most successful learning environment is a fusion of the two that allows unrestricted growth, experimentation and play within limiting boundaries.

The multi-media tutorials provided the students with the flexibility of time and place to work on problems and examples. The assignments included at the end of each video gave them the ability to self check the learning outcome. Students spoke favorably about the comprehensibility of individualized lessons and active role they got to play while learning. Multi-media tutorials provided valuable and supportive insight into the practical aspects. However, it should be noted that while these multi-media lessons provided excellent personalized learning, sometimes students got focused on completing the tasks at hand rather than understanding the concept and its practical implications. A teacher, especially in a lab-environment, tends to give more direct instructions, feedback and encouragement. The multi-media tutorials, even though highly communicative and knowledge building, can fail to engage the learner and to encourage higher-order thinking.

Results of this study can have broad applications in similar courses of higher education in Asia. The results will help understand different factors involved in choosing appropriate technology to use in a specific educational setting. Apart from providing the empirical data and analysis, the study also draws attention to pitfalls involved in utilizing ICT in laboratory environment. More such studies will help generalize strategies for optimizing the use of ICT in outcome based education and help evolve standards for e-learning content, delivery, and quality assurance.

It would be nice to see multi-media tutorials implementing adaptive techniques with varying degrees of complexity in future. Interaction, dynamic feedback and adaptive mechanisms can make sure that novice students are given encouraging inputs to build confidence and skills whereas proficient students are engaged with new challenges and content. If harnessed properly, multi-media lessons can encourage students to become independent learners gradually and effectively.

In conclusion, multi-media tutorials can act as a multiplier for capacity building efforts of students and they should be harnessed by educators for augmenting expansion as well as quality of education, encouraging blended learning. They help overcome limitations and problems imposed by traditional teaching methods and can be valuable tools for supporting the learning process in introductory engineering courses, helping students establish a basic foundation for further studies in the undergraduate curricula of engineering departments.

### Appendix A – Screen Shots
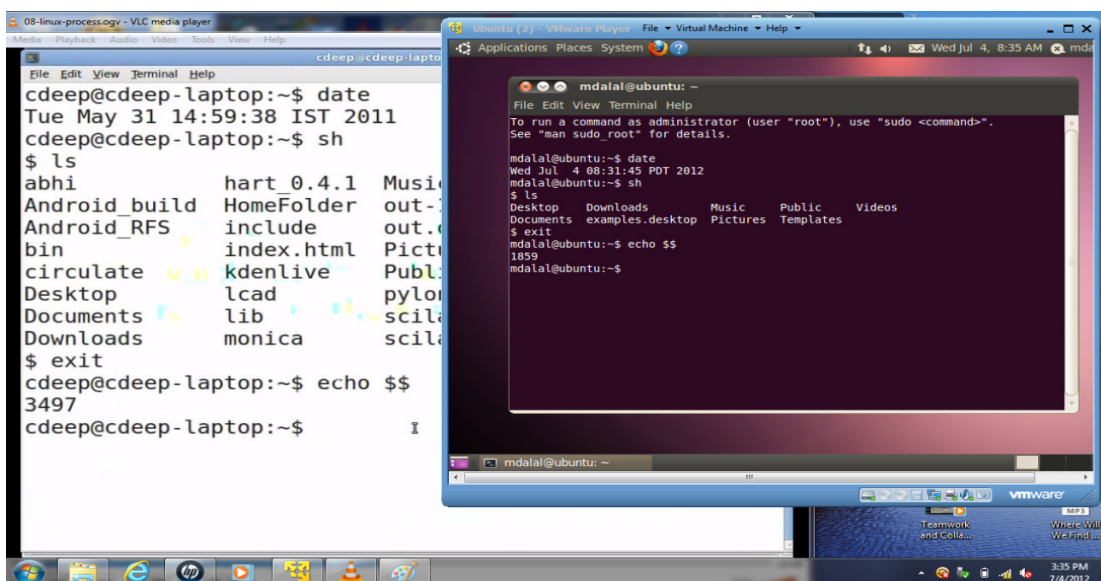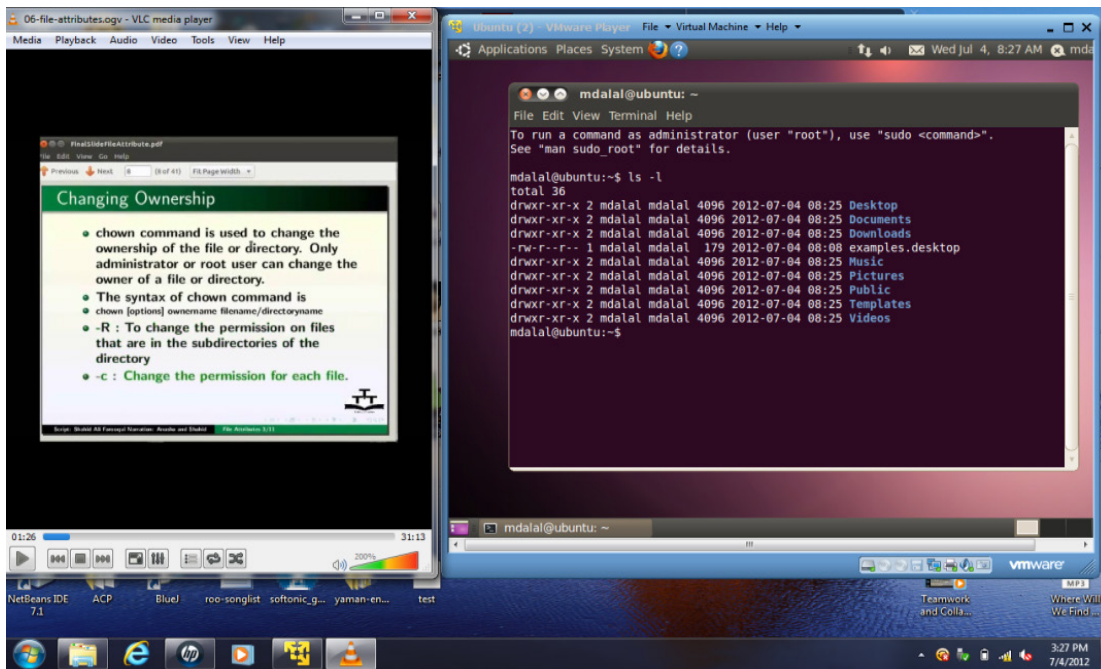
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