Formal Languages and Automata Theory

The course on finite automata and formal languages is important in the computer science and engineering curriculum as this course is a prerequisite for system software and compiler design courses and also the concepts learnt in this course are widely applicable in the computer science and related engineering fields.

Teaching the course on finite automata and formal languages is challenging because there are difficulties in understanding the formal language and automata theory concepts as the course is mathematical in nature. In addition, the conventional approach to the course followed a sequence of machine and then the corresponding language theory. The standard textbooks also recommended the same approach.

It is observed that this approach has failed to establish the context required for the study. A new approach to teaching the course on Formal Languages and Automata Theory is attempted. The course structure is redesigned to teach formal languages and corresponding automata followed by the properties of the respective languages according to the hierarchy of the formal languages. This flow of teaching makes students to understand the concepts and relate to the real time applications easily. **Activity oriented teaching learning** was attempted in the course and a **tutorial** was introduced for this course with an objective of increasing student participation. **Group activities** were attempted in tutorials which enhanced peer learning. **Course assessment** was done in terms of regular minor exams, quizzes based on GATE format and presentations. It is observed that this has resulted in increased participation and learning of students as evident in their performance. Students also felt that the pressure during examinations is reduced as they were comfortable with their learning through activities. At the end will discuss the experience of the course teachers and the results obtained.

COURSE DESIGN AND CLASSROOM ACTIVITY

As an introductory course to undergraduate students on formal language and automata theory where the purpose was to teach the formal languages and corresponding automata followed by the properties of the respective languages according to the hierarchy of the formal languages, finally it covers the application of the automata, and the course delivery is attempted with the following course learning objectives(CLO's) and topic level objectives(TLO's) for every chapter(one chapter TLO's shown below) written

according to Bloom's Taxonomy.

A**. Course Learning Objectives (CLO's)**

• Identify the different ways of denoting the formal languages.

• Explain the concepts of languages, grammars and automata.

• Construct the automata for a given formal language.(regular, context-free, context sensitive)

• Normalize the given context-free grammars.

• Use a pumping lemma to show that some languages are not regular / not context-free.

• Identify recursive and recursively enumerable languages and their relation with Turing Machines.

B. Topic level Objectives (TLO's)

Chapter Title: Introduction to Finite Automata

At the end of this chapter student should be able to:

• Explain the concept of DFA and draw the DFA for a given language (L3)

• Define a NFA and draw a NFA for a given language or regular exp (L3)

• Design a NFA's with Є-transitions for a given language or regular exp (L6)

• Design a DFA for a corresponding NFA (L6)

• Eliminate the ε-transitions from a given NFA and convert it to an equivalent DFA (L3)

Classroom Delivery:

Fig 1 shows the flow teaching the course in a classroom. For example, first we teach the regular language, then the finite state machine (FSM), and its properties along with the applications. This flow will help the students to understand the how a language is represented using regular expressions and constructing the corresponding the FSMs, exploring its properties and relating to the real time applications.

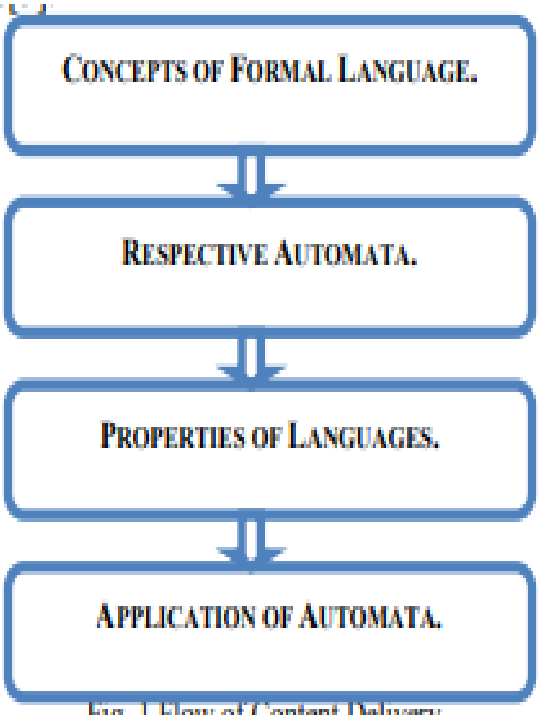


Fig. 1 Flow of Content Delivery

Example: Teaching Turing machine in the classroom It can be hard to convey the beauty, simplicity and insight of Turing Machines to introductory course to the students. We demonstrated an activity in the classroom on Turing Machine using students to act out the various parts of the Turing machine which helped the students to easily understand the concept. The approach followed for the activity is as fallows.

The activity is demonstration for the language

$L=\{a^n\ b^n\ |n\geq 1\}$

where I took the value of n=2. Initially all students face towards class. I lined up four students in front of the class to be the 'tape' and one student in front to be the R/W head'.

The Tape

Each student on the 'tape' represented either a or b and stood in the following pattern

...aabb…

- 'as' are represented by girls.
- 'bs' are represented by boys.

The Machine Head

• The 'machine head' student started in state A.

• student A with stick on his hand.

• When the machine head switched to state B, student hold two sticks on his hand.

• When machine R/W head is switched to State C and move towards left till us gets a girl facing black

board. Once we find a girl facing black board, R/W head switches to A.

• In order to 'write' on the tape, when we see girl in a state A, she turns towards black board and the boy who act as R/W will move towards right.

• When in state B if we see a boy then boy will turns towards black board.

• The boy who act as R/W head will move towards left and be in sate A.

• Now if we see a girl facing classroom then change state to B and turn towards black board.

• Then in B if we see a boy then he will turn towards black board.

The process will continue till for every girl there is a boy. Then finally R/W will be pointing to blank space where there are no students. Finally, all girls and boys are facing towards black board.

TUTORIAL ACTIVITY AND ASSIGNMENT

The course was taught in the classroom and it has supported by a tutorial. We framed some of the activities in the tutorial class which are as given below also shown in Figure 2

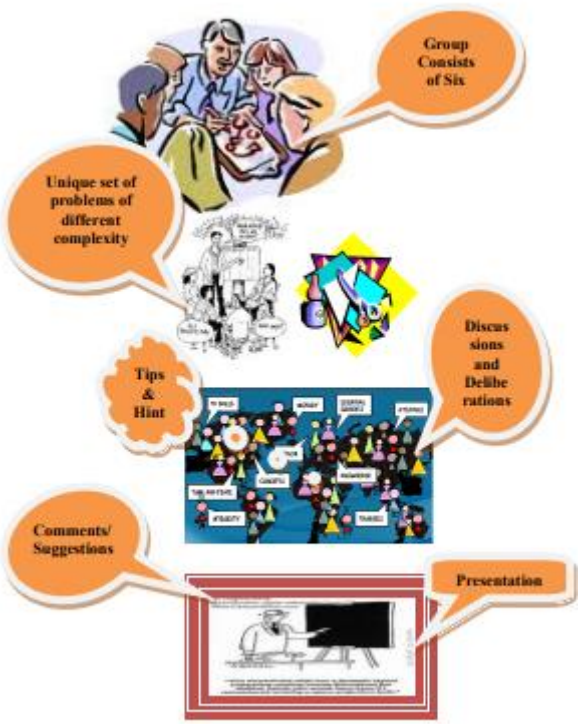


Fig. 2 Tutorial activity

A. Group activity

• A Group consists of six students.

• Each group is assigned a unique set of problems of different complexity.

• Each group need to make a discussion and deliberations to come out with a solution.

• The faculty gave tips and hints while solving the problems.

B. Presentation

• One student of each group presented the solution to the audience.

• During presentation faculty encouraged other students to give comments and discussions happened for better solution/ alternate solution in the allotted time.

C. Peer study

• A group of six students identify problems of different levels of Bloom's taxonomy related to the assigned chapter and submit the written copy to the faculty- in charge.

• Another group analyses the above problem and finds a suitable solution and submits the written solution to the faculty-in charge.

• Another group of students cross verifies the solutions prepared by their peers and finally prepares the softcopy and submits it to the faculty in charge.

• All the solutions so obtained are further verified by the faculty and made available to students at the end of the semester.

Assignment

At the end of every chapter and its discussion in tutorial an assignment was given, where the assignment was to implement the automata learnt in the respective chapters.

For example: Implementation of the conversion of NFA to DFA using subset construction method. The algorithm is as follows.

Steps of subset construction algorithm

• The initial state of the DFA is the set of all states the NFA can be in without reading any input.

• For any state {qi,qj,…,qk} of the DFA and any input a, the next state of the DFA is the set of all states of the NFA that can result as next states if the NFA is in any of the states qi,qj,…,qk when it reads a. This includes states that can be reached by reading a followed by any number of λ-transitions. Use this rule to keep adding new states and transitions until it is no longer possible to do so.

• The accepting states of the DFA are those states that contain an accepting state of the NFA

ASSESSMENT

For every activity done in the class as well as tutorial we have done an assessment. The classroom activity and learning, we tested through the minor exams. And the tutorial activity, peer study and assignment tested is explained as below and the criteria of assessment is given below.

CRITERIA OF ASSESSMENT:	**Assessment Weightage in %**
Minor Exams	**60**
Group Activities and assignment	**30**
Quiz	**10**

A. Minor Exams

• Two minor exams were conducted; the question papers are prepared based on the learning objectives.

• Our objective was to test the writing and problem solving ability of a student.

B. Quiz

• Two Quizzes' are conducted at the end of each unit.

• Our objective was to subject the students to GATE type
of questions, since this is one of the major subjects of GATE syllabus.

C. Group Activities in Tutorial

Group activity based assessment.

• Here our objective was to make the entire student community to participate in the group discussion and involve them in bringing out the solutions.

• Peer review intention was to test the confidence of the student in commenting the solution prepared by the peer.

Presentation based assessment

• Our objective was to test how a student is able to express the solution and convince the audience by his oral communication.

D. Assignment

Here the objective was to make them analyse how an automata works. Even the assessment was based on the learning happened by the student by the implementing the automata.

The implementation done by the students was executed in the tutorial where other students criticize, based on the overall results and understanding the assessment was done.

RESULTS AND OBSERVATIONS

Our main intention was to improve the student's participation in the classroom and enhance the problem solving ability.

Here we took a feedback from the students at the end of the activity.

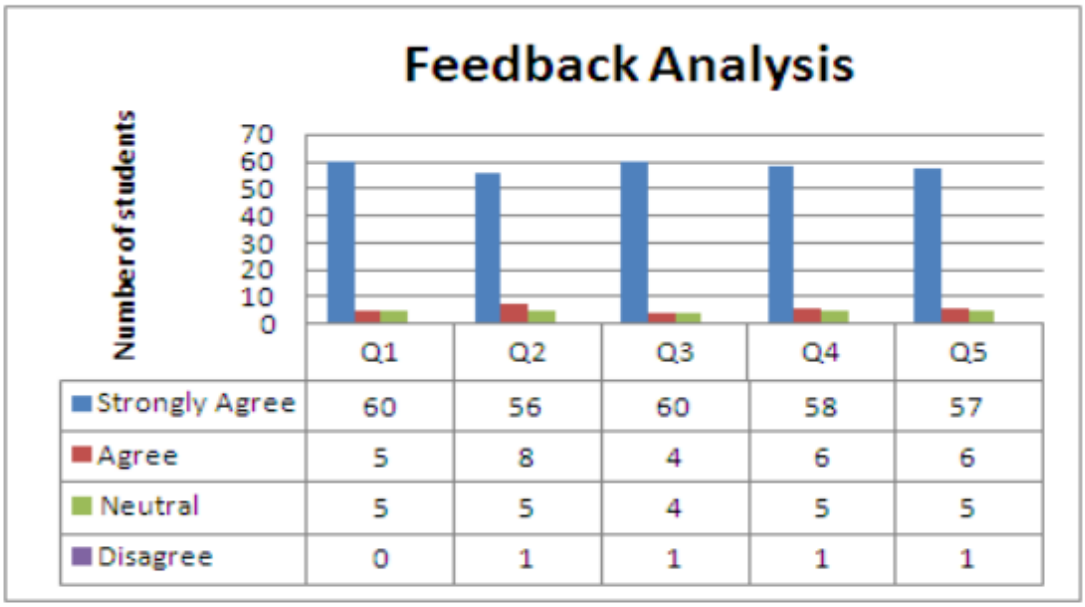
90% of the students says that the activity conducted in the classroom helped them to understand the concepts easily.

85 % of the students say that the tutorial class gave them a platform, where they could do the discussion and solve the problems which helped them to enhance the problem-solving ability.

Following questions are asked to the students at the end of the activity.

1. The classroom activity has helped us understand the concepts clearly. Where learning has improved. –
2. The tutorial activity has helped us to improve the problem-solving ability.
3. Assignment has helped in understanding the working of the automata.
4. Presentations helped us improve the confidence in the subject.
5. Ability to work in a team

The analysis is as shown in Figure 3.below:



	Q1	Q2	Q3	Q4	Q5
Strongly Agree	60	56	60	58	57
Agree	5	8	4	6	6
Neutral	5	5	4	5	5
Disagree	0	1	1	1	1

Fig. 3 Feedback analysis on the activity

Observations made by the Tutor:

• The course structure is redesigned to teach formal languages and corresponding automata followed by the properties of the respective languages according to the hierarchy of the formal languages. This flow of teaching makes students to understand the concepts and relate to the real time applications easily.

• Group activity helped in

• Better understanding of Concepts

• Improved the Problem-solving ability.

• Increased participation in discussion.

• Reduced the stress during the examination.

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