The impact of students’ behaviour, their approach, emotions and problem difficulty level on the performance prediction, evaluation and overall learning process during online coding activities

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Abstract:

Learning process while solving coding problems is quite complex to understand. It is extremely important to understand the skills which are required and gained during learning to code. As a first step to understand the students’ behaviour and approach during learning coding, two online coding assignments or competitions are conducted with a 1-hour time limit. A survey has been conducted at the end of each coding test and answers to different questions have been collected. In depth statistical analysis is done to understand the learning process while solving the coding problems. It involves lots of parameters including students’ behaviour, their approach and difficulty level of coding problems. The inclusion of mood and emotions related questions can improve overall prediction performance but difficulty level matters in the submission status prediction. Two coding assignments or competitions are analysed through in-depth research on 229 (first coding competition dataset) and 325 (second coding competition dataset) data points. The primary results are promising and these results give in depth insights about how learning to solve coding problems is affected by students’ behaviour, their approach, emotions and problem difficulty level.

Key Words: coding, emotions, learning, machine learning, problem solving, skills

Software Tools Used: Scikit learn, Microsoft forms, Microsoft teams, RapidMiner Studio (academic license),

1. Introduction

More than 1.5 million engineering students are graduating in India every year. The higher education system throughout world is now focusing on skills rather than traditional assessment systems. Mapping skills to the questions and evaluating different factors which affect the performance of students in coding assignments or competition, we have conducted two coding competitions or assignments and collected data through survey questions after each coding assignment.

Research work proposed in this paper is the first step towards mapping skills to the questions and evaluation of different factors which affect the performance of students in coding competitions or assignments. The automatic learning analytics is useful for web-based exams with multiple questions but survey questions are useful for coding competitions or assignments. Students’ strategies to learn programming are examined through data from the learning management system and automatic assessment tools in [1]. The data of 292 engineering students was used to gain a deep understanding of the student's learning process as well as type of learners in [1]. Code bench was deployed to collect data of introductory programming courses [2]. Data of 2058 students collected to understand the behaviour of students during programming activities [2]. Review of the main publications, the key milestones, the knowledge discovery cycle, different aspects of education data mining and learning analytics are covered in the survey presented by [3]. Integration of education data mining and learning analytics can produce fruitful results for all stakeholders of the education at all levels [3]. Italian Olympiads in Informatics (Olimpiadi Italiane di Informatica - OII) web based two distinct platforms are used to perform analytics on programming contest training systems for teachers and students [4]. The evaluation of a student’s behaviour while developing programming skills and solutions to assignments by using scratch environments [5]. Interactive web based programming platform has been proposed to collect keyboard and mouse data [6]. This data is used to classify learners in five affective states:

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boredom, frustration, distraction, relaxation and engagement with accuracy of 75% [6]. Integration of learning analytics in the e-learning assessment process to improve academic integrity is proposed by [7]. Written assignments of students are assessed by a machine learning framework which yields 93% accuracy as compared to 12% human accuracy [7]. Literature review and case studies of student’s programming processes through different educational data sets and learning analytics techniques are proposed in [8]. Code snapshots which are generated by 370 students of introductory undergraduate programming courses [9]. Machine learning models are used on the code snapshots to discover patterns and to predict final exam grades [9]. Multimodal learning analytics is proposed to discover student’s learning trajectories as well real time evaluation in offline or online tasks [10]. Review of Educational data mining, learning analytics, computer vision applied to assessment, and emotion detection is given in [11] for assessment of student’s behaviour in open ended programming tasks. In the above literature, learning analytics is applied to understand different factors and parameters which affect students’ performance in competitive programming and academic assignments. In this paper, two coding competitions or assignments were completed by students with 10 survey questions after each competition. Different factors and parameters which affect students’ performance while completion of coding competitions or assignments are analysed and machine learning models are also used to determine the outcome of assignments by using different factors and parameters. The difficulty and toughness of the coding problem can be determined from the assignment submission and their responses rather than complexity involved in the problems. This research work is the first step to propose learning analytics and machine learning methods to analyse different factors and parameters of students’ behaviour and their impact on the learning process of competitive coding.

2. Analysis of Coding Competitions

Coding, problem solving, and logical ability are important skills for engineers and coding-based assignments are very important for the development of these skills. Coding performance prediction and skill analysis are two important aspects covered in this research work. The impact of sleep and mood on the coding performance prediction and skill analysis are considered. During the study, two online coding assignments or competitions are given to students followed by ten survey questions related to their solution approach. Total 229 responses are recorded for ten survey questions after the first assignment and 325 responses are recorded for ten survey questions after second assignment. First seven survey questions are common in both the coding assignments. Last three survey questions of the first coding assignment are related to the opinion of students about coding activity so they are not included in this research. However, the last three questions of the second coding assignment are related to participants’ sleep status, mood and enthusiasm.

2.1 Question wise Analysis of Coding Competitions

1. Have you understood the problem completely before writing your programming solution?

![Fig.1 Comparison of participants’ responses against 1st question (a) Responses recorded after first coding assignment (b) Responses recorded after second coding assignment.](image-url)
Fig. 1 (a) and (b) show participants’ responses against 1st question for first and second coding assignments respectively. Problem of the first coding assignment was understood by 222 students (96.94%). Problem of the second coding assignment was understood by 284 students (87.38%). These responses give hints about the difficulty of the problems for both the coding assignments. This question is linked with the understanding skill of students.

2. Have you divided the given problem in sub problems before writing your code?

Fig. 2 Comparison of participants’ responses against 2nd question (a) Responses recorded after first coding assignment (b) Responses recorded after second coding assignment.

Fig. 2 (a) and (b) show participant’s responses against 2nd question for first and second coding assignments respectively. 176 students have divided problem for coding assignment 1 whereas 263 students have divided problem for coding assignment 2. This question is linked with problem solving skills.

3. Do you need to go through the problem statement again while writing your code?

Fig. 3 Comparison of participants’ responses against 3rd question (a) Responses recorded after first coding assignment (b) Responses recorded after second coding assignment.

Fig. 3 (a) and (b) show participant’s responses against 3rd question for first and second coding assignments respectively. 78 (34.06%) students have not revisited the problem during the first coding assignment whereas 47 (14.46%) students have not visited the problem during the second coding assignment. This question is related to analysis related skills.
4. Have you used the internet while writing your code?

![Graph showing responses to 4th question](image)

Fig. 4 Comparison of participants’ responses against 4th question (a) Responses recorded after first coding assignment (b) Responses recorded after second coding assignment.

Fig. 4 (a) and (b) show participant’s responses against 4th question for first and second coding assignments respectively. Internet was used by 107 (46.72%) students during the first coding assignment whereas 176 (54.15%) students used internet during the second coding assignment. This question is related to remember syntax and logical ability related skills.

5. How much time you have taken to complete this program?

![Graph showing responses to 5th question](image)

Fig. 5 Comparison of participants’ responses against 5th question (a) Responses recorded after first coding assignment (b) Responses recorded after second coding assignment.

Fig. 5 (a) and (b) show participant’s responses against 5th question for first and second coding assignments respectively. 112 (48.90%) students have taken less than 15 minutes to solve problem of coding assignment 1 whereas 37 (11.38%) students have taken less than 15 minutes to solve problem of coding assignment 2. This question is related with time management skills.

6. Have you tested your solution by giving different inputs before submission?
Fig. 6 Comparison of participants’ responses against 6th question (a) Responses recorded after first coding assignment (b) Responses recorded after second coding assignment.

Fig. 6 (a) and (b) show participant’s responses against 6th question for first and second coding assignments respectively. 195 students have tested their solution before submission of first coding assignment. 239 students have tested their solution before submission of second coding assignment. This question is related to testing and evaluation skills.

7. Have you submitted complete solution?

Fig. 7 Comparison of participants’ responses against 7th question (a) Responses recorded after first coding assignment (b) Responses recorded after second coding assignment.

Fig. 7 (a) and (b) show participant’s responses against 7th question for first and second coding assignments respectively. 207 (90.39%) students have submitted complete solution of coding assignment 1 whereas 252 (77.53%) students have submitted complete solution of coding assignment 2. This question is related to task completion or deadline management skills.

8. How was your mood when you started this activity?
Fig. 8. Responses recorded for 8th question after second coding assignment.

Fig.8 shows participant’s responses against 8th question for second coding assignment. 116 (35.69%) students have excellent mood whereas 146 (44.92%) students have good mood during second coding assignment. This question is related to status of mind and brain during coding activity (emotional status).

9. Have you taken enough sleep and feel good before this programming activity?

Fig. 9. Responses recorded for 9th question after second coding assignment.

Fig.9 shows participant’s responses against 9th question for second coding assignment. 245 (75.38%) students have taken enough sleep and feel good during second coding assignment. This question is related to relaxation of mind and brain during coding activity (physical and mental status).

10. Have you completed this activity with full enthusiasm?

Fig. 10. Responses recorded for 10th question after second coding assignment.

Fig.10 shows participant’s responses against 10th question for second coding assignment. 295 (87.12%) students have completed this activity with full enthusiasm during second coding assignment.
Fig. 10 shows participant’s responses against 10th question for second coding assignment. 295 (90.77%) students have completed this activity with full enthusiasm during second coding assignment. This question is related to feeling good about coding activity (Student’s preference about coding activity).

2.2 Overall Analysis of Coding competitions

There are two important criteria to determine successful completion of activity, we assume that a student have learnt new skills through these coding competitions, if they have submitted either complete solution or partial solution. The difficulty perceived by the student can be measured through the time taken by students to complete both the coding assignments as well as status of submission (full or partial or not submitted). First coding assignment was completed by 112 students within 15 minutes whereas second coding assignment was completed by only 37 students within 15 minutes. Second coding assignment problem was difficult for students as compared to first coding assignment problem. Approximately 90% students have submitted complete solution for first coding assignment whereas, approximately 82% students have submitted complete solution for second coding assignment. Answers of questions 5 and 7 are quite useful to determine the comparative difficulty of both coding assignment problems. Through learning analytics, we tried to identify, which factors are important to answer coding assignment problems in less than 15 minutes.

Table 1.1 Count of students who have completed first coding assignment based on different conditions.

| Understood | Divide | Revisit | Internet used | Testing | Submission | Time                  | Count |
|------------|--------|---------|----------------|---------|------------|-----------------------|-------|
| No         | No     | Yes     | Yes            | No      | Not submitted at all. | More than 15 minutes | 1     |
|            | Yes    |         |                | No      | No. Partial solution | More than 15 minutes | 1     |
|            |        |         |                |         | Not submitted at all. | More than 15 minutes | 1     |
| Yes        | Yes    | No      |                | No      | Yes. Complete solution | More than 15 minutes | 1     |
|            | Yes    |         |                | No      | No. Partial solution | More than 15 minutes | 1     |
|            |        |         |                | No      | Yes. Complete solution | More than 15 minutes | 1     |
| Yes        | No     | No      | No             | No      | Yes. Complete solution | Less than 15 minutes | 1     |
|            | Yes    |         |                | Yes     | Yes. Complete solution | Less than 15 minutes | 11    |
|            |        |         |                | Yes     |                       | More than 15 minutes | 2     |
|            | Yes    |         |                | No      | Yes. Complete solution | Less than 15 minutes | 1     |
|            |        |         |                | Yes     | Not submitted at all.  | More than 15 minutes | 1     |
|          |          |          | Yes. Complete solution | Less than 15 minutes | 3 |
|----------|----------|----------|------------------------|----------------------|--|
| Yes      | No       | No       | No. Partial solution   | More than 15 minutes | 1 |
|          |          |          | Yes. Complete solution | More than 15 minutes | 1 |
| Yes      | No       | No       | Yes. Complete solution | More than 15 minutes | 1 |
|          |          |          | Yes. Complete solution | More than 15 minutes | 1 |
| Yes      | No       | Yes      | Yes. Complete solution | More than 15 minutes | 1 |
|          |          |          | Yes. Complete solution | More than 15 minutes | 1 |
| Yes      | No       | No       | Yes. Complete solution | More than 15 minutes | 5 |
|          |          |          | Yes. Complete solution | More than 15 minutes | 4 |
|          |          |          | More than 15 minutes   | More than 15 minutes | 9 |
| Yes      | No       | No       | No. Partial solution   | More than 15 minutes | 1 |
|          |          |          | Yes. Complete solution | More than 15 minutes | 1 |
| Yes      | No       | Yes      | Yes. Complete solution | Less than 15 minutes | 32 |
|          |          |          | More than 15 minutes   | More than 15 minutes | 5 |
| Yes      | No       | Yes      | Yes. Complete solution | Less than 15 minutes | 1 |
|          |          |          | More than 15 minutes   | More than 15 minutes | 3 |
| Yes      | No       | Yes      | Yes. Complete solution | Less than 15 minutes | 1 |
|          |          |          | More than 15 minutes   | More than 15 minutes | 11 |
|          |          |          | More than 15 minutes   | More than 15 minutes | 3 |
| Yes      | No       | No       | No. Partial solution   | More than 15 minutes | 1 |
|          |          |          | Yes. Complete solution | Less than 15 minutes | 1 |
|          |          |          | More than 15 minutes   | More than 15 minutes | 3 |
| Yes      | No       | No       | No. Partial solution   | More than 15 minutes | 2 |
|          |          |          | Yes. Complete solution | Less than 15 minutes | 32 |
|          |          |          | More than 15 minutes   | More than 15 minutes | 18 |
| Yes      | No       | No       | No. Partial solution   | More than 15 minutes | 3 |
Not submitted at all. | More than 15 minutes | 1 |
|-------------------|-------------------|---|
| Yes. Complete solution | Less than 15 minutes | 3 |
| | More than 15 minutes | 5 |
| Yes | No. Partial solution | More than 15 minutes | 2 |
| Not submitted at all. | More than 15 minutes | 1 |
| Yes. Complete solution | Less than 15 minutes | 10 |
| | More than 15 minutes | 32 |

In order to determine weightage of different factors to answer first problem assignment within 15 minutes, refer table given below.

Table 1.2 Analysis of 112 students who have submitted first coding assignment solution within 15 minutes.

| Understood | Divide | Revisit | Internet used | Testing | Submission |
|------------|--------|---------|----------------|---------|------------|
| Yes-112    | Yes-90 | Yes-52  | Yes-33         | Yes-105 | Complete Solution-112 |
| No-0       | No-22  | No-60   | No-79          | No-7    | Partial solution-0    |
|            |        |         |                |         | Not submitted at all-0 |

Out of these 112 students who submitted the solution successfully, all (100%) have understood the problem. 22 (20%) students have not divided the problem into mini-goals whereas 90 (80%) students have divided the problem. 52 (46%) students have revisited the problem, 60 (54%) students did not revisit the problem. 79 (70%) students have not used internet whereas, 33 (30%) students have used internet to solve the problem. 105 (94%) students have tested their solution whereas, 7 (6%) students have not tested their solution.
Table 1.3 Count of Students who have completed second coding assignment based on different conditions.

| Understood | Divide | Revisit | Internet used | Testing | Submission | Time            | Mood    | Sufficient Sleep | Enthusiasm | Count |
|------------|--------|---------|---------------|---------|------------|-----------------|---------|-----------------|------------|-------|
| No         | No     | Yes     | No            | No      | No         | Less than 15 minutes | Good    | No              | Yes        | 1     |
|            |        |         |               |         |            | More than 15 minutes | Good    | Yes             | No         | 1     |
|            |        |         |               | Yes     | Complete   | More than 15 minutes | Average | No              | No         | 1     |
| Yes        | No     | Yes     | No            | No      | Partial    | More than 15 minutes | Good    | Yes             | Yes        | 1     |
|            |        |         |               | Yes     | Complete   | More than 15 minutes | Average | Yes             | Yes        | 1     |
| Yes        | No     | No      | Yes           | Yes     | Complete   | More than 15 minutes | Excellent | Yes             | Yes        | 10    |
|            |        |         |               | Yes     | Partial    | More than 15 minutes | Good    | Yes             | Yes        | 1     |
|            |        |         |               | Yes     | Complete   | More than 15 minutes | Average | No              | Yes        | 1     |
| Yes        | No     | No      | Yes           | Yes     | Not submitted | More than 15 minutes | Excellent | No              | Yes        | 1     |
| Yes        | Yes    | Yes     | No            | No      | Partial    | More than 15 minutes | Average | No              | Yes        | 1     |
| Yes        | No     | No      | No            | No      | Partial    | More than 15 minutes | Average | No              | Yes        | 1     |
|            |        |         |               | Yes     | Partial    | More than 15 minutes | Excellent | No              | Yes        | 1     |
|            |        |         |               | Yes     | Complete   | Less than 15 minutes | Excellent | Yes             | Yes        | 1     |
|            |        |         |               | Yes     | Complete   | More than 15 minutes | Excellent | No              | Yes        | 1     |
|            |        |         |               | Yes     | Complete   | More than 15 minutes | Good    | Yes             | Yes        | 3     |
| Yes        | No     | Yes     | No            | No      | More than 15 minutes | Average | No              | Yes        | 1     |
|            |        |         |               | Yes     | More than 15 minutes | Excellent | Yes             | Yes        | 1     |
|            |        |         |               | Yes     | Excellent  | Yes             | Yes        | 1     |

[Note: The table contains the count of students who have completed the second coding assignment based on different conditions such as understanding, divide, revisit, internet use, testing, submission, time spent, mood, sufficient sleep, and enthusiasm, along with the corresponding count.]
| No. Partial solution |          | Good | Yes | Yes | 1 |
|----------------------|----------|------|-----|-----|---|
| Yes. Complete solution | More than 15 minutes | Average | Yes | Yes | 1 |
|                      |          | Good  | Yes | Yes | 2 |
|                      |          | Poor  | Yes | Yes | 1 |
| Yes                  | No. Partial solution | More than 15 minutes | Average | No | No | 1 |
|                      |          | Excellent | Yes | Yes | 1 |
| Yes. Complete solution | More than 15 minutes | Excellent | Yes | Yes | 1 |
|                      |          | Good  | No  | Yes | 1 |
|                      |          | Yes   | Yes | 1 |
| Yes                  | No       | No       | Yes | Yes | 1 |
| Yes                  | No       | Not submitted at all. | More than 15 minutes | Average | Yes | No | 1 |
| Yes. Complete solution | More than 15 minutes | Good | Yes | Yes | 1 |
|                      |          | Poor  | No  | Yes | 1 |
| Yes                  | No       | No       | Yes | Yes | 1 |
| Yes                  | No       | No       | Yes | Yes | 1 |
| Yes                  | No       | More than 15 minutes | Excellent | No | Yes | 1 |
|                      |          | Good  | Yes | Yes | 1 |
| Yes                  | No       | More than 15 minutes | Less than 15 minutes | Excellent | Yes | Yes | 1 |
| Yes. Complete solution | More than 15 minutes | Average | No | No | 2 |
|                      |          | Excellent | Yes | Yes | 12 |
| Yes                  | No       | More than 15 minutes | Average | No | No | 1 |
| Yes                  | No       | More than 15 minutes | Good | No | Yes | 1 |
|                      |          | Yes   | Yes | 2 |
|                      |          | Yes   | Yes | 2 |
| Yes                  | No       | More than 15 minutes | Good | Yes | Yes | 1 |
| Yes. Complete solution | More than 15 minutes | Average | Yes | Yes | 2 |
|                      |          | Excellent | Yes | Yes | 1 |
|                      |          | Good  | No  | Yes | 3 |
|                      |          | Yes   | Yes | 3 |
|                      |          | Poor  | No  | Yes | 2 |
| Yes | No | No | No | Partial solution | More than 15 minutes | Average | Yes | Yes | 1 |
|-----|----|----|----|------------------|---------------------|---------|-----|-----|---|
| Yes | No | No | Yes | Yes | Excellent | Yes | Yes | 1 |
| Yes | No | No | Yes | Yes | Average | Yes | Yes | 1 |
| Yes | No | No | Yes | Yes | Excellent | No | Yes | 14 |
| Yes | No | No | Yes | Yes | Average | No | Yes | 2 |
| Yes | No | No | Yes | Yes | Excellent | Yes | Yes | 1 |
| Yes | No | No | Yes | Yes | Excellent | Yes | Yes | 2 |
| Yes | No | No | Yes | Yes | Excellent | Yes | Yes | 1 |
| Yes | No | No | Yes | Yes | Excellent | Yes | Yes | 2 |
| Yes | No | No | Yes | Yes | Excellent | Yes | Yes | 1 |
| Yes | No | No | Yes | Yes | Excellent | Yes | Yes | 1 |
| Yes | No | No | Yes | Yes | Excellent | Yes | Yes | 1 |
| Yes | No | No | Yes | Yes | Excellent | Yes | Yes | 3 |
| Yes | No | Partial solution | More than 15 minutes | Good | No | Yes | 8 |
|-----|----|------------------|---------------------|------|----|-----|---|
| Yes | No | Partial solution | More than 15 minutes | Average | Yes | Yes | 2 |
| Yes | No | Partial solution | More than 15 minutes | Good | No | Yes | 1 |
| Yes | No | Partial solution | More than 15 minutes | Yes | Yes | 2 |
| Yes | Not submitted at all | More than 15 minutes | Average | Yes | Yes | 1 |
| Yes | Yes, Complete solution | Less than 15 minutes | Good | Yes | Yes | 1 |
| Yes | Yes, Complete solution | Less than 15 minutes | More than 15 minutes | Average | No | No | 2 |
| Yes | Yes, Complete solution | Less than 15 minutes | More than 15 minutes | Yes | Yes | 2 |
| Yes | Yes, Complete solution | Less than 15 minutes | Good | No | Yes | 4 |
| Yes | Yes, Complete solution | Less than 15 minutes | Good | No | Yes | 2 |
| Yes | Yes, Complete solution | Less than 15 minutes | Excellent | Yes | Yes | 2 |
| Yes | Yes, Complete solution | More than 15 minutes | Average | No | Yes | 5 |
| Yes | Yes, Complete solution | More than 15 minutes | Average | Yes | No | 2 |
| Yes | Yes, Complete solution | More than 15 minutes | Average | Yes | Yes | 5 |
| Yes | Yes, Complete solution | More than 15 minutes | Excellent | No | Yes | 2 |
| Yes | Yes, Complete solution | More than 15 minutes | Excellent | Yes | No | 1 |
| Yes | Yes, Complete solution | More than 15 minutes | Good | Yes | No | 3 |
| Yes | Yes, Complete solution | More than 15 minutes | Poor | Yes | Yes | 2 |
Table 1.4 Analysis of 37 students who have submitted second coding assignment solution within 15 minutes.

| Understood | Divide | Revisit | Internet used | Testing | Submission | Mood    | Sufficient Sleep | Enthusiasm |
|------------|--------|---------|---------------|---------|------------|---------|-----------------|------------|
| Yes-35     | Yes-34 | Yes-14  | Yes-8         | Complete Solution-34 | Excellent-27 | Yes-31 | Yes-37         |
| No-2       | No-3   | No-23   | No-29         | Partial Solution-3   | Good-10     | No-6   | No-0           |
|            |        |         |               | Not submitted at all | Average-0   |        |                 |
|            |        |         |               |                     | Poor-0      |        |                 |

Out of 37 students who have submitted second coding assignment solution within 15 minutes, 35 (95%) students have understood the problem whereas 2 (5%) students have not understood it. 34 (92%) students have divided problem in mini-goals, whereas, 3 (8%) students have not divided the problem, 14 (38%) students have revisited the problem statement whereas, 23 (62%) students have not revisited problem statement, 8 (22%) students have used internet whereas, 29 (78%) have not used internet, 33 (89%) have tested the solution whereas, 4 (11%) have not tested the solution. 34 (92%) students have submitted complete solution whereas, 3 (8%) have submitted partial solution, 27 (73%) students have excellent mood whereas, 10 (27%) have good mood. 31 (84%) students have taken sufficient sleep whereas, 6 (16%) have not taken sufficient sleep, all 37 (100%) students were enthusiastic.

2.3 Difficulty Level of Coding Problems and Performance Measurement

Coding problems may be categorized as simple, moderate, difficult and very difficult for students. Difficulty level of coding problems can be predetermined by using intuition. In this research work, the difficulty level is determined through the submissions and responses of students. There are two difficulty level measurement. Complete solution was submitted by 90.39% students in first coding problem. Complete solution was submitted by 77.53% students in second coding problem. Relative difficulty level (DL) involved in this problem is given by equation 1.

$$DL = 1 - \left(\frac{\text{percentage of students who have submitted complete solution}}{100}\right)$$

According to above rule, difficulty level of first coding problem is around 0.0961 (9.61%) whereas difficulty level of second coding problem is around 0.2247 (22.47%). Difficulty level can also be measured by using time taken to submit the solution. The first coding problem was solved by 112 (48.90%) students within 15 minutes whereas second coding problem was solved by 37 (11.38%) students within 15 minutes. The second definition of difficulty level is given by equation 2.

$$DL_T = 1 - \left(\frac{\text{percentage of students who have submitted solution in less than 15 minutes}}{100}\right)$$

Where DLT is difficulty level with respect to time. So according to this definition, difficulty level of first problem is around 0.511 (51.1%) whereas difficulty level of second coding problem is around 0.8862 (88.62%).
Difficulty level measurement of coding problem is a relative measure and it is up to faculty, university and student community. Above two types of difficulty levels are proposed to show that there is a possibility to propose different types of difficulty levels according to the parameter to be investigated or skills to be measured.

Performance measurement can be done by using the information used by above two difficulty levels. Students who have submitted complete solution within 15 minutes can be awarded excellent performance, students who have submitted complete solution between 15 minutes to 1 hour can be awarded good performance, students who have partially submitted solution can be awarded average performance, and students who have not submitted solution can be awarded poor performance.

| Performance | No. of Students (%) |
|-------------|---------------------|
| Excellent   | 112 (48.90%)        |
| Good        | 95 (41.48%)         |
| Average     | 16 (6.99%)          |
| Poor        | 6 (2.62%)           |

Almost 90% students have excellent and good performance in first coding competition. Approximately 49% students have excellent performance in first coding competition.

| Performance  | No. of Students (%) |
|--------------|---------------------|
| Excellent    | 37 (11.38%)         |
| Good         | 215 (66.15%)        |
| Average      | 65 (20%)            |
| Poor         | 8 (2.46%)           |

Only 11.38% students have excellent performance in second coding competition, which clearly indicates the difficulty level of coding problem. Almost 86% students have good and average performance in second coding competition.

3. Application of Machine Learning in online competitive coding

Different machine learning algorithms are applied on the data collected through above two coding assignments to get insight into factors affecting performance in coding competition. RapidMiner studio academic version is used to apply machine learning in this research. Time to complete the coding assignment can be used to check student’s time management skills. It can also be used to measure comparative toughness of coding problems. Students have either completed coding problem in less than 15 minutes or more than 15 minutes. This is modelled as a binary classification problem for both the coding assignments.

In the first coding assignment data related to sleep, mood and enthusiasm were not collected, but collecting this information during second coding completion and using it in classifier modelling, improved F-score of the above binary classification problem for second coding assignment.

Submission status classification is not improved much due to sleep, mood and enthusiasm related features. Submission status classification largely depends on the difficulty level or complexity of the problems of coding assignments.
Table 1.7 Performance comparison of different classification algorithms to classify time required to complete the assignment (less than 15 minutes, more than 15 minutes) for first coding assignment

| Model           | F1 Measure | Standard Deviation | Gains | Total Time | Training Time (1,000 Rows) | Scoring Time (1,000 Rows) |
|-----------------|------------|--------------------|-------|------------|-----------------------------|---------------------------|
| Naive Bayes     | 0.7216     | 0.0708             | 22.0  | 1651.0     | 161.6                       | 217.4                     |
| Generalized Linear Model | 0.6461 | 0.0856             | 14.0  | 1181.0     | 262.0                       | 173.9                     |
| Logistic Regression | 0.7083 | 0.0526             | 20.0  | 946.0      | 266.4                       | 141.3                     |
| Fast Large Margin | 0.5350 | 0.1460             | 8.0   | 1727.0     | 144.1                       | 119.6                     |
| Deep Learning  | 0.6528     | 0.0411             | 16.0  | 1945.0     | 1358.1                      | 217.4                     |
| Decision Tree  | 0.6483     | 0.0787             | 6.0   | 981.0      | 117.9                       | 119.6                     |
| Random Forest  | 0.7050     | 0.0594             | 20.0  | 12516.0    | 0                            | 165.9                     |
| Gradient Boosted Trees | 0.6302 | 0.0520             | 10.0  | 11676.0    | 0                            | 554.6                     |
| Support Vector Machine | 0.6023 | 0.1204             | 18.0  | 2922.0     | 777.3                       | 228.3                     |

Table 1.7 shows performance comparison of different classification algorithms to classify time taken to solve the first coding assignment. F1 measure show that the performance of Naïve Bayes is best among all the algorithms. Here we are trying to classify the performance based on 229 data points. Logistic regression and random forest algorithms are performing well and they are on second place.

Table 1.8 shows performance comparison of different machine learning algorithms to classify the submission status of the assignments. Deep learning, decision trees, gradient boosted trees and support vector machine have best performance in the classification of submission status.

Table 1.8 Performance comparison of different classification algorithm to classify submission status for first coding assignment

| Model               | Accuracy (%) | Standard Deviation (%) | Gains | Total Time (sec) | Training Time (1000 Rows) | Scoring Time (1,000 rows) |
|---------------------|--------------|------------------------|-------|------------------|----------------------------|---------------------------|
| Naive Bayes         | 78.46        | 6.44                   | -16.0 | 1186.0           | 196.5                      | 120.9                     |
| Generalized Linear Model | 69.23 | 7.69                   | -30.0 | 1086.0           | 414.8                      | 263.7                     |
| Logistic Regression | 83.08        | 8.43                   | -12.0 | 1997.0           | 406.1                      | 285.7                     |
| Fast Large Margin   | 83.08        | 6.44                   | -8.0  | 3666.0           | 139.7                      | 472.5                     |
| Deep Learning       | 90.77        | 3.44                   | 0.0   | 1813.0           | 724.9                      | 285.7                     |
| Decision Tree       | 90.77        | 3.44                   | 0.0   | 1286.0           | 170.3                      | 120.9                     |
| Random Forest       | 78.46        | 6.44                   | -16.0 | 3154.0           | 139.7                      | 351.6                     |
| Gradient Boosted Trees | 90.77 | 3.44                   | 0.0   | 8895.0           | 449.8                      | 219.8                     |
| Support Vector Machine | 90.77 | 3.44                   | 0.0   | 3057.0           | 174.7                      | 307.7                     |
Table 1.9 shows performance comparison for different machine learning models to classify time to submit the second coding assignment. Support vector machine and gradient boosted trees have best performance in the prediction of time taken to complete the second coding assignment. Inclusion of mood and emotions related questions have improved performance of machine learning algorithms for second coding assignment. If table 1.7 and table 1.9 are compared then it clearly shows better performance in second coding problem due to inclusion of mood and emotions related questions. Mood and emotions also have impact on the performance of machine learning algorithms.

Table 1.9 Performance comparison of different classification algorithm to classify time taken to complete the assignment (less than 15 minutes, more than 15 minutes) for second coding assignment

| Model                     | F Measure | Standard Deviation | Gains | Total Time | Training Time (1,000 Rows) | Scoring Time (1,000 Rows) |
|----------------------------|-----------|--------------------|-------|------------|---------------------------|---------------------------|
| Naive Bayes                | 0.9413    | 0.0400             | 0.0000| 847.0      | 70.8                      | 100.0                     |
| Generalized Linear Model   | 0.9413    | 0.0400             | 0.0000| 936.0      | 116.9                     | 84.6                      |
| Logistic Regression        | 0.9413    | 0.0400             | 0.0000| 966.0      | 166.2                     | 84.6                      |
| Fast Large Margin          | 0.9460    | 0.0277             | 2.0000| 2088.0     | 230.8                     | 100.0                     |
| Deep Learning              | 0.9413    | 0.0400             | 0.0000| 2322.0     | 732.3                     | 223.1                     |
| Decision Tree              | 0.9413    | 0.0400             | 0.0000| 1391.0     | 86.2                      | 100.0                     |
| Random Forest              | 0.9413    | 0.0400             | 0.0000| 3398.0     | 70.8                      | 253.8                     |
| Gradient Boosted Trees     | 0.9514    | 0.0298             | 4.0000| 14243.0    | 987.7                     | 200.0                     |
| Support Vector Machine     | 0.9520    | 0.0296             | 4.0000| 3016.0     | 110.8                     | 153.8                     |

Table 1.10 Performance comparison of different classification algorithm to classify submission status for second coding assignment

| Model                     | Accuracy (%) | Standard Deviation | Gains | Total Time | Training Time (1,000 Rows) | Scoring Time (1,000 Rows) |
|----------------------------|--------------|--------------------|-------|------------|---------------------------|---------------------------|
| Naive Bayes                | 82.69        | 0.0969             | 16.0  | 1449.0     | 135.4                     | 153.8                     |
| Generalized Linear Model   | 78.13        | 0.0898             | 6.0   | 1738.0     | 353.8                     | 169.2                     |
| Logistic Regression        | 83.80        | 0.0930             | 18.0  | 3059.0     | 344.6                     | 376.9                     |
| Fast Large Margin          | 82.75        | 0.1024             | 16.0  | 6117.0     | 341.5                     | 492.3                     |
| Deep Learning              | 82.75        | 0.0703             | 16.0  | 2657.0     | 609.2                     | 246.2                     |
| Decision Tree              | 87.02        | 0.0637             | 20.0  | 1939.0     | 107.7                     | 207.7                     |
| Random Forest              | 83.86        | 0.0543             | 14.0  | 5577.0     | 110.8                     | 507.7                     |
| Gradient Boosted Trees     | 84.91        | 0.0706             | 16.0  | 11069.0    | 341.5                     | 384.6                     |
| Support Vector Machine     | 82.46        | 0.0741             | 14.0  | 5972.0     | 190.8                     | 500.0                     |

Table 1.10 shows performance comparison of different classification algorithm to classify submission status for second coding assignment. Decision tree has best performance as compared to other algorithms for second coding assignment. If we compare table 1.8 with table 1.10 then it clearly shows that the performance of machine learning algorithms is good for classification of submission status.
during first coding assignment or competition. Inclusion of mood and emotions related questions have improved overall performance of all algorithms but still performance of machine learning algorithms is good in the prediction of submission status for first coding assignment. Prediction of submission status is not improved remarkably due to inclusion of emotions and mood related questions because the second problem is very difficult as compared to first problem. Here difficulty plays role in the prediction of submission status of both the coding assignments.

4. Conclusions and Discussion

Overall statistical analysis shows great promise if students’ behaviour is recorded automatically through interactive web technology and multi modal learning analytics. Here we have taken first step to understand the learning process while solving coding problems. Table 1.1 clearly shows that the during first coding assignment students who have understood the problem, divided the problem, not revisited the problem, not used internet, and tested solution have highest possibility to solve coding problem in less than 15 minutes. The first coding problem was not difficult as compared to second coding problem which also plays major role while prediction of submission status. Table 1.3 shows that students who have submitted solution in less than 15 minutes have either excellent or good mood. Majority students who have submitted complete solution also have either excellent or good mood. The inclusion of mood and emotions related questions can improve overall prediction performance but difficulty level matters in the submission status prediction. Learning process while solving coding problem is quite complex and involves lots of parameters. This is the first step to understand the contribution of different parameters in the learning process while solving the coding problems. We have conducted in depth research on 229 and 325 data points. The results are promising and we have learned a lot about how learning to solve coding problems is affected by students’ behaviour and their approach, emotions and problem difficulty level.

5. Future work

This research work is conducted based on survey questions. We have just taken first step to understand how students’ behaviour and their approach affects the learning process while solving the coding problems. As a future work, we would like to understand students’ behaviour though automatic and interactive web technology as well as multimodal learning analytics. We would like to extend the scale of our research by including more data points. We would like to generate skill cards for each student as well as we want to understand impact of each skill in the performance prediction of different machine learning models. Students who are graduated with a degree in engineering with percentage or CPI (absolute or relative credit system). The terms score card or mark sheet or transcript or grade card are widely used throughout the world. There should be a concept of skill card after every semester so that students know about their performance in particular skills. Mapping of questions to skills in each subject is the key idea to generate skill card for students. Skill cards can be generated by combining skills obtained through all subjects in one semester. Coding competitions and assignments are also useful to generate skill cards for students. Universities can have one dedicated office to implement skill card generation and distribution policies. Learning can be personalized by giving skill card to students so they can assess their skills and they come to know about their strength and weakness in terms of skills. Students have clear idea about their performance in particular skills so they can make strategies to improve or retain their performance in particular skills. The skill card concept is useful to students and university both. Students can come to know about skills to improve through skill card whereas university can generate huge data set. Learning analytics can be applied to the data set gathered through skill cards.
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