Modeling Learning Motivation of Students Based on Analysis of Class Evaluation Questionnaire

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Introduction

Questionnaire used in our university
Introduction

Questionnaire used in our university

Goal of this research

Utilize results of the questionnaire to improve the classes in the future
Introduction

Q. Were you satisfied with this course?

1 2 3 4 5
No Yes

Student with high learning motivation

Student with low learning motivation
Introduction

Q. Were you satisfied with this course?

Course A: Difficult

[1] Yes
[2] 2
[3] 3
[4] 4
[5] No

Course B: Easy

[1] No
[2] 2
[3] 3
[4] 4
[5] Yes

I learned a lot. 😊

I don’t wanna study... 😞

high motivation

low motivation
Q. Were you satisfied with this course?

Course A: Difficult

- 1: I learned a lot.
- 2: Effortless Class.
- 3: Good!
- 4: I don’t wanna study.
- 5: Too easy.

Course B: Easy

- 1: Too easy.
- 2: Boring.
- 3: Light motivation
- 4: Effortless Class.
- 5: No
Introduction

Q. Were you satisfied with this course?

Course A: Difficult

1. I learned a lot. 😊
2. I don’t wanna study.

Course B: Easy

1. I don’t wanna study.
2. Effortless Class. Good!

I. Insufficient evaluation!
II. Useless for course improvement

high motivation
low motivation

Too easy.
Boring.

Yes
No
Solution

Develop learner’s model which

In our study

Define learning motivation

Represent learning motivation
Quantitative Learner’s Motivation Model (QLMM)

What’s QLMM?

A model composed of basic elements representing attitude of students towards the attended courses

→ Quantification of those elements represents the general level of learning motivation
Quantitative Learner’s Motivation Model (QLMM)

**Learning Motivation**

```
``The will to learn the contents provided in the class”
```

To calculate it we consider three elements

(1)

(2)

(3)

Corresponds to the points of view included in the

```
``Application of the ARCS model of motivational design” [Keller et al.(1987)]
``Use if the ARCS motivational model in courseware design” [Keller et al.(1988)]
```
Quantitative Learner’s Motivation Model (QLMM)

Figure 1. Relationship of QLMM and ARCS model
Quantitative Learner’s Motivation Model (QLMM)

Learner’s Model

- Hometown
- Sex
- Result
- Attendance
- Motivation

QLMM

Interest
Usefulness in the Future
Self-Evaluation
Satisfaction

ARCS Model

Attention
Relevance
Confidence
Satisfaction

Figure 1. Relationship of QLMM and ARCS model
Quantitative Learner’s Motivation Model (QLMM)

Figure 1. Relationship of QLMM and ARCS model

QLMM

Interest
Usefulness in the Future
Self-Evaluation
Satisfaction

ARCS Model

Attention
Relevance
Confidence
Satisfaction

Figure 1. Relationship of QLMM and ARCS model
Quantitative Learner’s Motivation Model (QLMM)

Figure 1. Relationship of QLMM and ARCS model
Designed an original questionnaire

For purpose of estimation of learning motivation

Ten questions,
  four choice-questions
  six free answer-question

Inquire about four elements on the basis of the ARCS model
Questionnaire Design Based on QLMM

(1) Did you have an interest in this course?

(2) Do you think participating in this course will help you in the future?

(3) Were you satisfied with this course?

(4) Did you attend this course with a desire to learn?

Figure 2. Question examples from the questionnaire

Answers in the questionnaire were designed as choice fields (with 5-point scale)

This allows quantification of each element
Questionnaire Design Based on QLMM

(1) Did you have an interest in this course?

(2) Do you think participating in this course will help you in the future?

(3) Were you satisfied with this course?

(4) Did you attend this course with a desire to learn?

Figure 2. Question examples from the questionnaire

Applied the term of "Confidence" from the ARCS model
Questionnaire Design Based on QLMM

Conduct similar questionnaire at the beginning and at the end of the course

Assumption: Learning motivation changes with progress of class material

Check the transition by comparing the quantified motivation at each time point

Experiment: Predict the motivation of learners

Using answers collected from the questionnaire performed
Questionnaire Design Based on QLMM

Prediction procedure

\[ Q = \{q_1, q_2, \ldots, q_i, \ldots, q_m\} \]

\[ X = \{x_1, x_2, \ldots, x_j, \ldots, x_n\} \]

\[ Q \]

\[ X \] student group containing

Step 1.

mean average

\[ \mu_i = \frac{1}{n} \sum_{j=1}^{n} r_{i,j} \] (1)

standard deviation

\[ \sigma_i^2 = \frac{1}{n-1} \sum_{i=1}^{n} r_{i,j} - \mu_i \] (2)
Questionnaire Design Based on QLMM

Prediction procedure

Step 2.

\[ s_{i,j} = \begin{cases} 
1 & \text{if } r_{i,j} \geq \mu_i \pm \sigma_i \\
-1 & \text{if } r_{i,j} \leq \mu_i \pm \sigma_i \\
0 & \text{otherwise} 
\end{cases} \quad (3) \]

\[ M_j = \sum_{i=1}^{m} s_{i,j} \quad (4) \]
Questionnaire Design Based on QLMM

Prediction procedure

Step 3.

\[
M \mid M_j \leq |m|, \; M_j \in Z
\]

Learner's motivation is

\[
\begin{cases} 
\text{high} & \text{if } M_j \geq 1 \\
\text{low} & \text{if } M_j \leq -1 \\
\text{neither high nor low} & \text{otherwise}
\end{cases}
\]
Evaluation of Proposed Model

Carried out a questionnaire for nine courses

Included both compulsory and elective courses offered to undergraduates of 1st to 3rd year

Conducted the questionnaires at the beginning and at the end of the course

Obtained a total of 5,040 answers

Attempt to automatically predict student’s learning motivation
Evaluation of Proposed Model

Performed the Evaluation Experiment

Verify the validity of the predicted learning motivation

Evaluation criteria

\[ P = \frac{n}{A} \]  \hspace{1cm} (6) \hspace{1cm} \[ R = \frac{n}{B} \]  \hspace{1cm} (7)

- \( n \): Number of predictions based on three elements matching self-evaluation
- \( A \): Number of all responses predicted using three elements
- \( B \): Number of all responses inferred by self-evaluation of learners

\[ F = \frac{2 \times P \times R}{P + R} \]  \hspace{1cm} (8)
# Evaluation of Proposed Model

## Learner’s Motivation

<table>
<thead>
<tr>
<th>Learner’s Motivation</th>
<th>Precision</th>
<th>Recall</th>
<th>F-measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Motivation</td>
<td>$0.45 \pm 0.22 S.D.$</td>
<td>$0.88 \pm 0.12 S.D.$</td>
<td>$0.57 \pm 0.20 S.D.$</td>
</tr>
<tr>
<td>Neither</td>
<td>$0.96 \pm 0.05 S.D.$</td>
<td>$0.58 \pm 0.20 S.D.$</td>
<td>$0.70 \pm 0.16 S.D.$</td>
</tr>
<tr>
<td>High Motivation</td>
<td>$0.44 \pm 0.16 S.D.$</td>
<td>$0.89 \pm 0.15 S.D.$</td>
<td>$0.57 \pm 0.17 S.D.$</td>
</tr>
<tr>
<td>All</td>
<td>0.62</td>
<td>0.78</td>
<td>0.61</td>
</tr>
</tbody>
</table>

### Fisher’s exact test

$p = 3.61e$  

Results of the classification are statistically significant.
Prediction "Neither high nor low" was easier than other classes

Examined in detail the responses

The number selected by learner indicated to

In some of the learners the perception of numerical values was subjective
Discussion

To solve this problem

- Add two classes
  - "Slightly low motivation"
  - "Slightly high motivation"

- Re-examine the combination of scores for each class
Figure 3. Possible score combinations applicable for different classes.
Discussion

Combination 1.

Combination 2.

Combination 3.

Low Motivation
Slightly Low Motivation
Neither
Slightly High Motivation
High Motivation

Figure 3. Possible score combinations applicable for different classes
Conclusion

Proposed an original (QLMM)

→ Quantification of three elements represent the general level of learning motivation

(1)
(2)
(3)

From result of Fisher’s exact test

→ Results of classification were statistically significant
Future work

- Increase the number of classes from three to five
- Re-examine the scores depending on different combinations of classes
# Questionnaire Result

<table>
<thead>
<tr>
<th>Course</th>
<th>Number of Student</th>
<th>Number of respondents</th>
<th>Collect rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course A</td>
<td>74</td>
<td>73</td>
<td>98.6%</td>
</tr>
<tr>
<td>Course B</td>
<td>63</td>
<td>62</td>
<td>98.4%</td>
</tr>
<tr>
<td>Course C</td>
<td>70</td>
<td>66</td>
<td>94.3%</td>
</tr>
<tr>
<td>Course D</td>
<td>69</td>
<td>64</td>
<td>92.8%</td>
</tr>
<tr>
<td>Course E</td>
<td>75</td>
<td>68</td>
<td>90.7%</td>
</tr>
<tr>
<td>Course F</td>
<td>181</td>
<td>160</td>
<td>88.4%</td>
</tr>
<tr>
<td>Course G</td>
<td>54</td>
<td>44</td>
<td>81.5%</td>
</tr>
<tr>
<td>Course H</td>
<td>75</td>
<td>58</td>
<td>77.3%</td>
</tr>
<tr>
<td>Course I</td>
<td>108</td>
<td>55</td>
<td>50.3%</td>
</tr>
</tbody>
</table>
Calculate Example

Predict learner’s motivation

Number of questions is three

\[ Q = \{q_1, q_2, q_3\} \]
\[ X = \{x_1, x_2, x_3, x_4, x_5\} \]

Obtained values for evaluated items for each learner:

\[ \{r_{1,j}, r_{2,j}, r_{3,j}\} = \{(5, 1, 4, 3, 4), (5, 1, 4, 2, 3), (4, 2, 3, 1, 2)\} \]

\[ r_{i,j} \]

mean average
\[ \{\mu_1, \mu_2, \mu_3\} = \{3.4, 3.0, 2.4\} \]

standard deviation
\[ \{\sigma_1, \sigma_2, \sigma_3\} = \{1.52, 1.58, 1.14\} \]
Calculate Example

Predict learner’s motivation

In this case:

learners $x_1$ obtains $\{s_{1,1}, s_{2,1}, s_{3,1}\} = \{1, 1, 1\}$ and $M_1 = 3$

Indicates that the learning motivation in learner $x_1$ is “high”
Fisher’s exact test

Whether there is a statistically significant association between the two groups

When it is significantly related:

\[ p < \alpha \]
Fisher’s exact test

<table>
<thead>
<tr>
<th>Low Motivation</th>
<th>Neither</th>
<th>High Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>88</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>230</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>66</td>
</tr>
</tbody>
</table>

Number of predictions based on three elements

Number of inferred by self-evaluation

- Low Motivation
- Neither
- High Motivation

3*3
## Fisher’s exact test

**Result of each course:**

<table>
<thead>
<tr>
<th>Course</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course A</td>
<td>2.12E-09</td>
</tr>
<tr>
<td>Course B</td>
<td>5E-14</td>
</tr>
<tr>
<td>Course C</td>
<td>5.22E-02</td>
</tr>
<tr>
<td>Course D</td>
<td>4.72E-05</td>
</tr>
<tr>
<td>Course E</td>
<td>4.21E-07</td>
</tr>
<tr>
<td>Course F</td>
<td>1.44E-07</td>
</tr>
<tr>
<td>Course G</td>
<td>1.24E-03</td>
</tr>
<tr>
<td>Course H</td>
<td>1.94E-07</td>
</tr>
<tr>
<td>Course I</td>
<td>1.97E-07</td>
</tr>
</tbody>
</table>
### Re-examine result

<table>
<thead>
<tr>
<th>Combination</th>
<th>Precision</th>
<th>Recall</th>
<th>F-measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination1</td>
<td>0.41±0.14 S.D.</td>
<td>0.43±0.19 S.D.</td>
<td>0.52±0.26 S.D.</td>
</tr>
<tr>
<td>Combination2</td>
<td>0.40±0.07 S.D.</td>
<td>0.39±0.15 S.D.</td>
<td>0.35±0.08 S.D.</td>
</tr>
<tr>
<td>Combination3</td>
<td>0.44±0.24 S.D.</td>
<td>0.41±0.17 S.D.</td>
<td>0.42±0.15 S.D.</td>
</tr>
<tr>
<td>All</td>
<td>0.42</td>
<td>0.41</td>
<td>0.43</td>
</tr>
</tbody>
</table>

#### Motivation Levels
- Low Motivation
- Slightly Low Motivation
- Neither
- Slightly High Motivation
- High Motivation
### Re-examine result

#### Combination1 result:

<table>
<thead>
<tr>
<th>Category</th>
<th>Precision</th>
<th>Recall</th>
<th>F-measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Motivation</td>
<td>0.17±0.29 S.D.</td>
<td>0.17±0.29 S.D.</td>
<td>0.17±0.29 S.D.</td>
</tr>
<tr>
<td>Slightly Low Motivation</td>
<td>0.21±0.26 S.D.</td>
<td>0.47±0.41 S.D.</td>
<td>0.26±0.29 S.D.</td>
</tr>
<tr>
<td>Neither</td>
<td>0.41±0.10 S.D.</td>
<td>0.47±0.36 S.D.</td>
<td>0.42±0.20 S.D.</td>
</tr>
<tr>
<td>Slightly High Motivation</td>
<td>0.60±0.20 S.D.</td>
<td>0.22±0.03 S.D.</td>
<td>0.48±0.01 S.D.</td>
</tr>
<tr>
<td>High Motivation</td>
<td>0.77±0.15 S.D.</td>
<td>0.81±0.25 S.D.</td>
<td>0.76±0.13 S.D.</td>
</tr>
<tr>
<td>All</td>
<td>0.43</td>
<td>0.43</td>
<td>0.42</td>
</tr>
</tbody>
</table>
Re-examine result

<table>
<thead>
<tr>
<th>Motivation Type</th>
<th>Precision</th>
<th>Recall</th>
<th>F-measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Motivation</td>
<td>0.11±0.19 S.D.</td>
<td>0.17±0.29 S.D.</td>
<td>0.13±0.23 S.D.</td>
</tr>
<tr>
<td>Slightly Low Motivation</td>
<td>0.14±0.17 S.D.</td>
<td>0.17±0.17 S.D.</td>
<td>0.15±0.17 S.D.</td>
</tr>
<tr>
<td>Neither</td>
<td>0.41±0.10 S.D.</td>
<td>0.47±0.36 S.D.</td>
<td>0.42±0.20 S.D.</td>
</tr>
<tr>
<td>Slightly High Motivation</td>
<td>0.62±0.16 S.D.</td>
<td>0.17±0.07 S.D.</td>
<td>0.25±0.09 S.D.</td>
</tr>
<tr>
<td>High Motivation</td>
<td>0.70±0.24 S.D.</td>
<td>0.93±0.12 S.D.</td>
<td>0.77±0.18 S.D.</td>
</tr>
<tr>
<td>All</td>
<td>0.40</td>
<td>0.38</td>
<td>0.40</td>
</tr>
</tbody>
</table>
### Combination3 result:

<table>
<thead>
<tr>
<th></th>
<th>Precision</th>
<th>Recall</th>
<th>F-measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Motivation</td>
<td>0.17±0.29 S.D.</td>
<td>0.17±0.29 S.D.</td>
<td>0.17±0.29 S.D.</td>
</tr>
<tr>
<td>Slightly Low Motivation</td>
<td>0.38±0.54 S.D.</td>
<td>0.33±0.29 S.D.</td>
<td>0.30±0.34 S.D.</td>
</tr>
<tr>
<td>Neither</td>
<td>0.44±0.10 S.D.</td>
<td>0.69±0.23 S.D.</td>
<td>0.53±0.12 S.D.</td>
</tr>
<tr>
<td>Slightly High Motivation</td>
<td>0.44±0.51 S.D.</td>
<td>0.06±0.05 S.D.</td>
<td>0.10±0.09 S.D.</td>
</tr>
<tr>
<td>High Motivation</td>
<td>0.77±0.16 S.D.</td>
<td>0.82±0.23 S.D.</td>
<td>0.77±0.12 S.D.</td>
</tr>
<tr>
<td>All</td>
<td>0.44</td>
<td>0.41</td>
<td>0.37</td>
</tr>
</tbody>
</table>