Note: Only a subset (30%) of the original data is given here.

1 Logistic Regression

We consider the logistic regression model. An uninformative prior will be used first, followed by an informative prior based on past research. The results obtained will be compared with the model fit derived using MLE.

In this section, the dataset used will be from a study conducted in a medical school to determine the effectiveness of games in the classroom, which was analysed in Ang et al. (2018), and Ang et al. (2020). We will attempt to analyse a subset of this data using alternative approaches not used in the papers.

In this study, students were grouped into 3 groups - group 0, group 1 and group 2. Group 0 was the control group, in which students were taught the usual way. Groups 1 and 2 were taught using gamification in the classroom, but both groups were exposed to types of classroom interventions.

The effectiveness of the games is measured through self-directed learning traits, which consists of motivation, control, initiative and self-efficacy. These traits were measured by administering the PRO-SDLS survey (Stockdale and Brockett, 2011) to the students on the first day of the course, and after the course has concluded.

Each question in the survey is corresponds to one of the self-directed learning traits, and the overall score of a trait is measured by averaging the responses used for a particular question. For example, the questions used to measure 'motivation' are questions 3, 8, 11, 14, 16, 18, and 20. Suppose a student responds 5, 4, 3, 4, 3, 5, and 1 to those questions, then his motivation score would be $(5 + 4 + 3 + 4 + 5 + 1)/7 = 3.14$. This strategy of averaging scores from the same construct has been used previously, such as in Cazan and Schiopca (2014), Hall (2011), and Schulze et al. (2017).

To assess if the games have worked, the pre and post course survey scores for each student were calculated. Subsequently, the difference between the post and pre survey scores were calculated, and the games are said to work if the difference in scores is positive. If the difference in scores are less than or equal to 0, it is said that the games did not work on the student.

In this section, we will attempt to study the impact of gamification exercises on initiative,

one of the traits which was found to have improved in Ang et al. (2020). This will be done by fitting a logistic regression model to the data.

Define response variable Y as,

$$Y = \begin{cases} 1 & \text{if post - pre scores } > 0, \\ 0 & \text{otherwise,} \end{cases}$$

and for each student, define dummy variables X_1 and X_2 such that,

$$X_k = \begin{cases} 1 & \text{if student is in group } k, \\ 0 & \text{otherwise,} \end{cases} \quad \text{for } k = 1, 2.$$

Let $p = P(Y = 1)$. Then, we can write the logistic regression model as

$$\log \frac{p}{1-p} = \alpha + \beta_1 X_1 + \beta_2 X_2,$$

where α is the baseline log odds (log odds when the student is in group 0 - no intervention). β_1 and β_2 are the increase in log odds when the student is in group 1 and group 2, respectively (the intervention groups). Our goal is to obtain parameter estimates for α, β_1 and β_2, and use them to assess the impact of the various types of classroom interventions on the 'initiative' trait of students.

1.1 Logistic Regression using MLE

To provide a benchmark for our MCMC fit, the model was first fitted using MLE to estimate the parameters. The summary of this model is given in Table 1.

Coefficient	Estimate	Standard Error	p-value
α	-0.241	-0.599	0.5495
β_1	1.128	2.200	0.0278
β_2	1.253	1.766	0.0774

Table 1: Summary of logistic regression fit

The p-values in Table 1 is tested under the null hypothesis that the various parameters are equal to zero. Both β_1 and β_2 are significant under $p = 0.1$, although only β_1 is significant under

$p = 0.05$. This suggest that both groups 1 and 2 have an increased odds of success (increased initiative levels after the intervention).

1.2 MCMC

Two models were fitted to the data using MCMC. The first is one which uses a non informative flat prior for all parameters.

The second model utilizes the findings in Ang et al. (2020), based on qualitative feedback from students, that there were indeed increased initiative levels post intervention, for both the non control groups. Furthermore, we assume that for the control group, there is no change in initiative levels pre and post intervention. Therefore, the following priors are used,

$$\begin{aligned} \alpha &\sim N(0, 0.5^2) \\ \beta_1 &\sim N(1, 1.5^2) \\ \beta_2 &\sim N(1, 1.5^2). \end{aligned} \tag{1}$$

In particular, a weakly informative prior was chosen for β_1 and β_2 to reflect our belief that gamification indeed helps. A more informative prior was used for α to support our belief that the control group has no impact on the students.

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