An Optimal Study Group Repartition to Improve its Members Performance in STEM

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ABSTRACT

This study aims to address the gender gap in STEM performance by exploring an optimal and gender-mixed class/group configuration that can lead to improvements in its members' abilities. To achieve this, a stochastic optimization algorithm, Differential Evolution, is employed to group individuals with similar characteristics but different features. The study considers various factors, such as background knowledge, motivation, parental education, and home environment, among others, to find the most relevant facets of students for improving science and mathematical abilities. The research questions focus on identifying the intrinsic elements in the dataset that might impact the group's performance and drawing a bridge between a personal development process, group behavior, and natural evolution using an evolutionary algorithm. The study will involve 30 primary and secondary education scholars, and ethical approval is required before data collection. The research findings could contribute to reducing the gender gap in STEM fields, such as mathematics and computer science.

KEYWORDS

Insert keyword text, Insert keyword text, Insert keyword text, Insert keyword text

1 Background

In the light of the importance of mathematics to society and to the individual, considerable effort was devoted to determine the factors that explain the variation in class performance between genders. An example, also addressed in this study, is related to several studies reporting discrepancies in math test scores in favour of boys [8], [3]. Literature offers explanations for the gender inequalities in mathematics-related fields, essentially identifying two categories of factors biological or psychological and social or cultural influences [7], teacher's attitude [5], the perceived level of parental expectations, motivation [2]. Also, regarding math test scores [8]. The impact of emotional factors in mathematics results is also studied in [9], where grades of students are predicted using attitudes towards mathematics. In the concerning problem of women under-representation in Science, Technology, Engineering, Mathematics fields [6] [4], study [1] established that the fundamental stage that impacts choosing career pathways is located between 6 to 15 years. Thus, studying the key aspects that influence mathematics abilities, aiming to reduce the observed gender gap in mathematics results in school, might beneficially impact career aspirations and help reducing the gender proportion differences in fields like Computer Science, Mathematics or Engineering. Considering the concept of class, predominantly used in the analyses of social divisions, this study aims to find an optimal and gender mixed class/group configuration that leads to improvements in its members abilities in STEM. This grouping problem is addressed using a stochastic optimization algorithm (Differential Evolution), a successful-reported approach for unsupervised clustering problems (the number of clusters is not known apriori) [10]. This study explores the idea that some defining features of a student such as: age, average individual study time invested, attitude towards competition and some external factors like parents level of education or parents level of expectations can be used in this attempt. In order to model such a transfer we need to build a bridge between a personal development process and the influence of the collective behaviour. A first step would be to identify clusters by grouping individuals with some similar characteristics but also different features, in such a way that they will/can enhance their potential. The clustering task can be solved using algorithms inspired by the natural evolution metaphor.

2 Problem Definition and Research Questions

The following research questions aim to find their answers within this study:

1. Which facets of students are the most relevant for improving mathematical abilities for members in a study group?

2. What intrinsic elements in dataset, that are not visible from exploratory analysis or descriptive statistics, might have impact on the groups performance?
3. Can we draw a bridge between a personal development process, a group behaviour and natural evolution transposed in an evolutionary algorithm?

3 Methods and Assumptions

The methodology for this study involves recruiting eligible participants who are scholars enrolled in primary and secondary education programs. Ethical approval is needed from the School Ethics Committees and National Ethics Council for Scientific Research Involving Human Participants prior to data collection. As the participants are unable to provide informed consent, it must be sought from the local authority, teachers and parents, and confidentiality of data is maintained throughout the data collection process and analysis dissemination. The study aims to gather information about disposition-related variables and demographic and environment-related variables from approximately 30 participants with similar ages and education stages. Primary and secondary schools will be collaborated with to recruit participants and the research will be conducted after school hours in available study rooms.

3.1 Dataset Construction

This study will use qualitative methods, such as interviews, focus groups, and observations, as well as quantitative methods such as mathematics tests and questionnaires, to collect data on factors that impact mathematics abilities. 30 participants of similar age and education stage will be recruited from primary and secondary schools.

3.2 Grouping Procedure

Group configuration is important in determining productivity. Homogeneous groups are more productive in simpler tasks, while heterogeneous groups are more productive in more complex tasks. The ideal group is cohesive and has congruent goals. The study aims to define an appropriate similarity measure for participants. Similarity is computed using a formula that aggregates similarities between each variable. One approach to grouping is to join students with different attitudes towards mathematics to observe the influence of students with an affinity for mathematics on others. Another approach is to group students with similar environmental characteristics but different mathematics scores and assess group performance in solving simple and complex tasks.

4 Unsupervised Clustering Problem

The unsupervised clustering problem involves partitioning a set of instances into clusters based on certain properties. Effective clustering maximizes intra-cluster similarities and minimizes inter-cluster similarities. The problem is formulated as an optimization problem with two variables quantifying the similarities. A modified Differential Evolution (DE) algorithm is used for clustering, where the number of clusters is not predefined. Each individual in the population corresponds to a partition and has components representing the number of clusters and affiliation to a cluster. The algorithm involves initialization, mutation, crossover, and selection steps, repeated until a stopping condition is met. The mutation strategy involves selecting three distinct individuals from the population and obtaining a donor vector based on their differences. The obtained elements are evaluated based on the objective function. The process continues until the stopping condition is met.

5 Preliminary Study and Discussion

A group of 10 friends (ages 26-31) were given descriptions of six fictional characters representing fractions of 10-year-old children in primary school. They individually solved a set of mathematics problems before working in pairs to solve the same problems. No improvement was observed in the group work compared to individual performance. Further investigation led to the formation of three gender-mixed groups. One outperformed the others due to similarities in attitude toward competition, information processing styles, mathematics scores, parental education, and expectations. Although no solid conclusions were drawn, the exercise provided insight into the study's design elements.

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