

Learner Group Formation Using Constraint Optimization

Extended Abstract

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ABSTRACT

Learner group formation manually based on multiple criteria often fails due to its complexity and time limitations of practitioners. This paper presents a novel binary integer programming approach which models learner group formation problem based on Jigsaw Collaborative Learning Flow Pattern (CLFP) using constraint optimization techniques. Suggested approach supports adaptive collaboration and provides flexibility when reformulating learner groups.

CCS CONCEPTS

•**Human-centered computing** → HCI theory, concepts and models;

KEYWORDS

Computer Supported Collaborative Learning (CSCL), Jigsaw CLFP, Binary Integer Programming, Constraint Optimization

1 INTRODUCTION

In the context of collaborative learning Jigsaw CLFP is adopted when several small groups of students are facing to study a lot of information for the resolution of the same problem. This CLFP has two major phases and inherits intrinsic constraints which are mandatory to be satisfied and extrinsic constraints which are induced by contextual factors. Intrinsic constraints applied in both phases are described along with the model in section 2.

2 METHODS

Given a total set of T tasks, N students group formation problem can be modeled as follows:

$$\text{Minimize } \sum_{i=1}^N \sum_{j=1}^N \sum_{k=1}^T X_{ik} X_{jk} C_{ij} \quad (1)$$

subject to

$$\sum_{k=1}^T X_{ik} = 1 \quad \forall i \in \{1, \dots, N\} \quad (2)$$

$$\sum_{i=1}^N X_{ik} \geq G \quad \forall k \in \{1, \dots, T\} \quad (3)$$

$$\sum_{i=1}^N B_{im} X_{ik} \geq 1 \quad \forall k \in \{1, \dots, T\}, \forall m \in \{1, \dots, M\} \quad (4)$$

X_{ik} denotes assigning student i to task k , X_{jk} denotes assigning student j to task k . For each pair of students i and j , the cost C_{ij} is included as a term in the objective function precisely when i and

j are assigned to the same task k . Each individual i is assigned to only one task k (2). Each task k is assigned to a minimum number of students G (3). Constraint (4) ensures during phase 02, at least one student from each task (from phase 01) is presented in each Jigsaw group. B_{im} represents student i allocation to Jigsaw group m , X_{ik} denotes previous task assignment of student i to task k . Cost function parameters could be used to incorporate a number of extrinsic constraints.

We have linearized quadratic terms appear in the objective function (1) to obtain performance gains as follows:

$$\text{Minimize } \sum_{i=1}^N \sum_{j=1}^N \sum_{k=1}^T W_{ijk} C_{ij} \quad (5)$$

Following three linear constraints were introduced in order to ensure that $W_{ijk} = X_{ik} X_{jk}$.

$$W_{ijk} \leq X_{ik} \quad (6)$$

$$W_{ijk} \leq X_{jk} \quad (7)$$

$$W_{ijk} \geq X_{ik} + X_{jk} - 1 \quad (8)$$

Further, by changing the objective function, flexibility towards regrouping of students while minimizing changes to existing grouping structures is facilitated. Given a total set of T tasks, N students we can regroup students while minimizing the cost incurred during task assignment (9).

$$\text{Minimize } \sum_{i=1}^N \sum_{k=1}^T X_{ik} C_{ik} \quad (9)$$

In this scenario cost term represents initial task allocations as follows:

$C_{ik} = 0$, if student i was previously assigned to task k

$C_{ik} = 1$, if student i was not previously assigned to task k

By minimizing the objective function, algorithm minimizes the number of students that were previously assigned to different groups, but now become assigned to the same group. The algorithm was implemented using Python and SQLite database. Gurobi Optimizer version 6.5. was used to solve different problem instances using real world data sets for group formation design, regrouping design and for performance analysis.

3 CONCLUSION

Algorithm formulates and reformulates learner groups providing optimal grouping results within seconds. Obtaining near-optimal results via approximations would be advantageous in complex scenarios i.e., different extrinsic constraints applied for grouping due to limited computation time allowed in classroom scenarios.