Optimizing group dynamics with computational intelligence in digital drama pedagogy

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Abstract

The aim of this study is to use Computational Intelligence (CI), specifically the Flying Foxes Optimization (FFO) algorithm, to create psychosocially homogeneous student groups in virtual drama education. The goal is to enhance collaboration and creativity by reducing differences in psychosocial characteristics within groups, creating an environment that supports effective theatrical preparation. The methodology was applied to data from 1,077 students, resulting in the automatic formation of 173 groups, each consisting of 4 to 9 members. Group homogeneity was assessed using the coefficient of variation, with results indicating satisfactory levels of homogeneity across all groups. Additionally, a multivariate analysis of covariance (MANCOVA) confirmed the discriminant validity of the proposed method. Univariate tests revealed significant differences across psychosocial characteristics, highlighting the effectiveness of the method in forming distinct, well-structured groups. The findings suggest that this methodology enhances group formation processes and optimizes group dynamics.

Keywords: Computational Intelligence, Flying Foxes Optimization, virtual drama education, group dynamics

Introduction

The integration of theatre education into online and virtual worlds represents a pivotal shift in how we approach teaching and creativity in the digital era (Anderson et al., 2009; Cziboly & Bethlenfalvy, 2020; Philip & Nicholls, 2007; Zakopoulos et al., 2023). For years, theatre education has been a valuable tool in fostering children's development, helping to improve creativity, social skills, and emotional intelligence (Bolton, 2007; Kladaki & Mastrothanasis, 2023; Nilson, 2022; Rasmussen, 2010; Wagner, 2002). As the educational landscape increasingly migrates to digital environments, it becomes essential to ensure that these benefits are not only preserved but expanded in virtual environments (Dhawan, 2020; Topping et al., 2022). The introduction of theatre education in these environments brings both opportunities and challenges, especially when it comes to organizing student groups effectively (Siciliano, 2021).

The careful structuring of student groups plays a crucial role in the success of theatre education, as collaborative and creative work depends on the dynamic between participants (Mastrothanasis et al., 2024). Computational Intelligence (CI) offers a promising tool to automate this process using characteristics such as students' age, interests, and abilities, ensuring balanced and cooperative groups (Mastrothanasis et al., 2021, 2023). Moreover, CI can use psychosocial data, enabling educators to form groups that naturally promote teamwork and minimize conflicts, thus supporting the collaborative nature of theatre education (Ikegwu et al., 2023; Moreno et al., 2012, 2021).

In virtual settings, theatre education transcends the physical limitations of traditional classrooms, offering students the chance to engage in creative expression without geographical barriers. Additionally, virtual environments can accommodate a significantly larger number of participants than traditional settings, creating new opportunities for collaboration but also presenting challenges in effectively managing group dynamics. Despite CI's growing presence in education, its application in theatre education—particularly in group formation—remains underexplored (Mastrothanasis et al., 2024). CI has the potential to simplify and improve this process by optimizing group dynamics and ensuring that students collaborate effectively while enjoying a personalized learning experience (Pinninghoff J et al., 2017; Wang et al., 2007; Zervoudakis et al., 2020; Zheng et al., 2018).

Automating student group formation using CI ensures not only a simple process but also an intelligent one (Krouska et al., 2023; Lin et al., 2010; Wang et al., 2007). CI algorithms can process and evaluate a variety of factors, identifying patterns and relationships that might not be obvious through simple statistical analyses (Pizzo et al., 2019; Yang, 2020). This allows for the creation of diverse and harmonious groups in terms of interpersonal dynamics. By incorporating CI into the educational framework, educators and institutions can optimize the grouping process, customize learning experiences, and create an environment beneficial for both academic excellence and personal growth (Zervoudakis et al., 2020).

Recent research has shown that CI methods, such as genetic algorithms, mayfly and particle swarm optimization (Zervoudakis & Tsafarakis, 2020), have been used successfully to form groups based on a variety of student characteristics, including learning styles, emotional characteristics, and performance anxiety (Alhunitah & Menai, 2016; Krouska et al., 2019; Mastrothanasis et al., 2021, 2023). One approach that stands out is the Flying Foxes Optimization (FFO) algorithm (Zervoudakis & Tsafarakis, 2023). FFO offers an optimization method inspired by the survival behavior of flying foxes during heatwaves (Zervoudakis & Tsafarakis, 2023). This method, combined with dynamic parameter adjustment through a Fuzzy Rule-Based System (FRBS), allows FFO to optimize group formation efficiently (Aalloul et al., 2023). Its success in solving real-world problems makes it an effective tool in educational contexts, particularly for theatre education in virtual settings, where group dynamics are critical.

FFO's ability to adapt to different optimization scenarios by dynamically adjusting its parameters without the need for manual fine tuning offers significant advantages in terms of accuracy and efficiency. Its application in forming student groups for theatre education in virtual environments can help educators overcome challenges related to group size, psychosocial characteristics, and interpersonal dynamics (Mastrothanasis et al., 2024). The integration of FFO into the CI framework allows for an adaptable approach to group formation, one that can address the complexities of modern educational settings.

1. Purpose of the research

This study aims to design and develop an innovative mechanism using Computational Intelligence (CI), based on the Flying Foxes Optimization (FFO) methodology (Zervoudakis & Tsafarakis, 2023), to form psychosocially homogeneous groups in virtual drama education. Effective learning in virtual drama depends heavily on the collaboration between participants, and the formation of groups with similar psychosocial characteristics is essential to promote a supportive environment for both collaboration and creativity. The FFO methodology is a key component of this process, as it forms homogeneous groups, optimizing both learning and creative outcomes.

In addition to focusing on group homogeneity, the study also considers the practical aspect of group management for educators, ensuring that the groups formed are of a manageable size. By applying CI techniques through the FFO methodology, the mechanism will analyze a variety of psychosocial attributes to create optimally structured groups. This approach equips drama educators with a powerful tool, improving the collaborative learning experience and enhancing the creative potential of their students in virtual environments.

2. Method

2.1. Dataset

To collect the psychosocial data required for this study, we used the psychosocial adaptation test (Chatzichristou et al., 2007). This standardized instrument, completed by teachers, contains 112 questions assessing the frequency of specific behaviors using a five-point Likert scale. The instrument consists of four subscales: (a) social competence (27 items), (b) academic competence (29 items), (c) emotional competence (25 items), and (d) behavior problems (31 items).

The social competence subscale evaluates three dimensions: assertiveness (DH), interpersonal communication (DE), and peer cooperation (SO). Assertiveness measures children's leadership and initiative (6 items), interpersonal communication examines behaviors that promote social interaction (15 items), and peer cooperation assesses collaborative behavior in group tasks (6 items). The academic competence subscale looks at motivation (KI), organization (OS), school effectiveness (SA), and school adjustment (SX). Motivation assesses the drive for goal achievement (4 items), while organization examines planning and time management skills (13 items). School effectiveness evaluates overall success in school (6 items), and school adjustment assesses adaptation to the school environment (6 items). Emotional competence is measured across self-control (AE), emotion management (DS), empathy (E), and stress management (Dt). Self-control refers to regulating emotions (8 items), emotion management focuses on emotional awareness (5 items), empathy assesses understanding others' emotions (5 items), and stress management evaluates coping strategies (7 items). The behavior problems subscale includes interpersonal adjustment (DP), intrapersonal adjustment (EP), and hyperactivity (YD). Interpersonal adjustment measures aggressive behaviors (9 items), intrapersonal adjustment assesses emotional difficulties (9 items), and hyperactivity/ impulsivity evaluates attention-related issues (13 items). High scores in this subscale reflect lower levels of psychosocial adjustment.

The dataset includes responses from 1,077 fourth to sixth-grade students from various schools in Greece. Descriptive statistics reveal that the average scores for assertiveness, interpersonal communication, and peer cooperation were 48.9, 51.2, and 50.7, respectively. In academic competence, motivation averaged 46.5, and school effectiveness scored 46.7. Emotional competence revealed an average self-control score of 47.1, with stress management averaging 48.1. Behavior problems showed average scores of 53.6 for both interpersonal and intrapersonal adjustment.

2.2. Application design and evaluation

The aim of this study is to minimize the differences between the characteristics of individuals within each group. To achieve this, the objective function is defined as the sum of distances between all students' characteristics in each group. Pairwise distances between students are calculated to determine these differences.

The study considered groups of 4 to 9 students as appropriate for preparing a theatrical performance. If a group's size falls outside this range, the solution is rejected. The FFO algorithm was adapted for optimal group formation by first randomly generating the position of each "flying fox" as a 2D table. Each row represents a student (from a total of 1077), while columns represent the maximum number of groups ([1077/4] = 269).

Since this is a discrete optimization problem, the Smallest Position Value (SPV) technique was applied. Each student is assigned to the group with the lowest corresponding value. A modification was made to speed up the algorithm's convergence, where students are randomly selected to form groups based on the proximity of their characteristics.

Additionally, when a student from a random group is moved to a new group, the process considers the student's characteristics and their pairwise distances. If the student is from a group of 4, they swap places with another student in the new group who has the greatest distance in characteristics.

After groups are formed, the solutions are evaluated for homogeneity using the coefficient of variation (CV) (Bindu et al., 2019). A CV close to 0 indicates homogeneity, while values closer to 1 indicate heterogeneity. Groups are classified as either satisfactorily homogeneous ($0.00 < CV \leq 0.40$) or unsatisfactorily homogeneous ($CV > 0.40$) (Zervoudakis et al., 2020). The final solution is further tested for discriminant validity using MANCOVA (Farrell, 2010).

3. Results

FFO is executed 50 times until 100,000 function evaluations are reached. The best solution ever found has a value of 59,060 according to the objective function, with an average value of 59,067.02 and an s.d. of 1.95. The convergence characteristic curve of FFO is depicted in Figure 1.

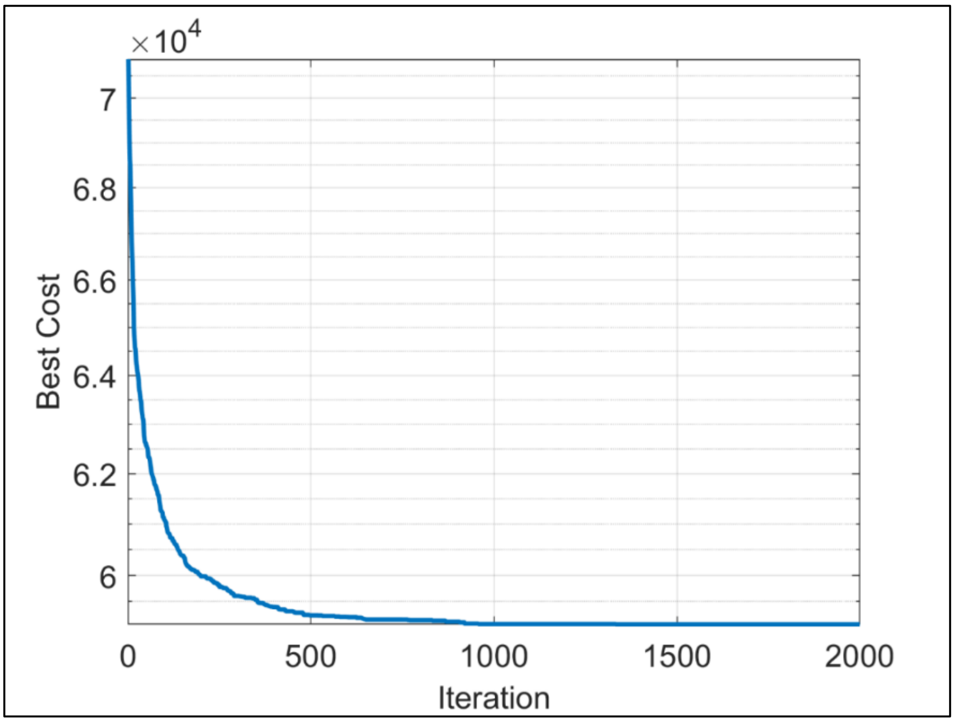

Figure 1. Convergence characteristic curve of FFO

The process described above resulted in the creation of 173 distinct groups of students, each formed based on the similarity of their psychosocial profiles as defined by the fourteen subscales. These groups were carefully structured to ensure that members within each group had comparable characteristics, supporting the goal of enhancing collaboration and creativity in a virtual drama education setting.

Each group consisted of 4 to 9 members, which was deemed appropriate for the effective preparation of a theatrical performance. The average number of members per group was 6.23, with a standard deviation of 0.78, indicating that the group sizes were consistently within the desired range. This consistency was important not only for the performance of the algorithm but also for ensuring that each group remained manageable for educators in practical terms.

The distribution of group sizes varied across the 173 groups. Only one group consisted of four members, representing approximately 1% of the total groups. Groups with five members accounted for 13% of the total, with 22 groups fitting this category. The majority of groups, however, were made up of six members—98 groups in total, representing 57% of all groups. This was the most common group size, reflecting the tendency of the algorithm to form balanced groups that optimize both psychosocial compatibility and practical management. Additionally, 42 groups (24% of the total) consisted of seven members, while nine groups (5%) had eight members. Finally, one group comprised nine members, again representing approximately 1% of the total.

In terms of homogeneity, the groups displayed a high degree of similarity within the fourteen psychosocial characteristics. The mean homogeneity across the groups ranged from 0.07 to 0.36, suggesting that the algorithm successfully minimized the differences between group members, ensuring that students within the same group shared compatible psychosocial traits.

The results from the multivariate tests of the MANCOVA analysis, conducted to assess the discriminant validity of the proposed method, revealed significant effects across all tests. Specifically, Pillai's Trace yielded a value of 6.95, $F(2408, 12656) = 5.19$, $p < .001$, indicating that the proposed method accounts for significant variance in the dependent variables. Similarly, Hotelling's Trace reported a value of 53.63, $F(2408, 12448) = 19.80$, $p < .001$, further supporting the discriminant validity of the method. Finally, Roy's Largest Root showed a value of 30.74, $F(172, 904) = 161.55$, $p < .001$, providing additional evidence that the method successfully distinguishes between groups based on their psychosocial characteristics.

The univariate results from the MANCOVA analysis also indicate significant differences across all dependent variables. For the social competence subscale (DHI), the analysis revealed a sum of squares of 78,053.52, $F(172, 904) = 28.02$, $p < .001$, confirming that the groups formed are significantly different in terms of their social competence. Likewise, significant results were found for the interpersonal communication subscale (DE), with $F(172, 904) = 42.53$, $p < .001$, and peer cooperation subscale (SO), with $F(172, 904) = 39.54$, $p < .001$. These findings indicate that the proposed method effectively forms groups with distinct levels of social competence.

In the domain of academic competence, significant differences were also observed. For motivation (KIN), the sum of squares was 90,172.94, $F(172, 904) = 29.57$, $p < .001$, and for organization (OS), $F(172, 904) = 37.38$, $p < .001$. Similarly, school effectiveness (SA) showed significant variation between groups, with $F(172, 904) = 40.87$, $p < .001$. These results suggest that the method successfully differentiates students based on their academic skills.

Emotional competence also demonstrated significant results. The self-control subscale (AE) had a sum of squares of 74,058.17, $F(172, 904) = 25.79$, $p < .001$, while emotion management (DS) was found to have $F(172, 904) = 28.57$, $p < .001$. Further, empathy (E) and stress management (DSt) showed significant differences between groups, with $F(172, 904) = 27.85$, $p < .001$ and $F(172, 904) = 32.01$, $p < .001$, respectively.

Behavioral issues were also examined, with significant results observed for interpersonal adjustment (DP), $F(172, 904) = 26.44$, $p < .001$, and intrapersonal adjustment (EP), $F(172, 904) = 26.67$, $p < .001$. Additionally, hyperactivity/impulsivity (YDS) demonstrated significant variation, $F(172, 904) = 26.85$, $p < .001$.

4. Discussion

The findings of this study emphasize the critical role of psychosocial homogeneity in forming student groups for virtual drama education. Homogeneity within these groups creates a collaborative environment, which is essential for the success of theatrical preparation and performance. When students share similar psychosocial characteristics, they communicate more effectively, make decisions more cohesively, and experience a sense of creative harmony (Bailey & Skvoretz, 2017; Mannell et al., 2006). These elements are vital for achieving the objectives of theatre education and producing a coherent and polished final performance (Mastrothanasis et al., 2024).

The application of the CI FFO-based methodology offers theatre educators a powerful tool for managing student groups more effectively. By understanding the unique characteristics of each group, educators can tailor their teaching methods and resources to better meet the specific needs of their students. This individualized approach is key to optimizing educational outcomes and ensuring that each theatrical engagement is both meaningful and relevant. The ability to customize instruction based on the psychosocial profiles of students enhances both learning and creativity.

One of the primary advantages of the FFO methodology is its accuracy and efficiency (Darwish, 2018; Fan et al., 2020). The methodology is highly adaptable and can process a diverse range of students without being constrained by the amount or type of data being assessed. Its speed in generating solutions also makes it practical for real-world educational settings, where time and resources are often limited. Additionally, unlike other metaheuristic algorithms, FFO's fuzzy self-tuning method eliminates the need for manual parameter initialization, simplifying its implementation (Tsafarakis et al., 2020; Valdez et al., 2021).

The introduction of this innovative methodology marks a significant advancement in digital drama education. Using CI to structure student groups sets a new standard for the organization of digital theatre education. The methodology not only enhances pedagogical efficiency but also supports the development of critical competencies that are increasingly important across a wide range of fields. The adaptability of the FFO algorithm makes it a versatile tool for addressing the evolving demands of digital education, ensuring that theatre educators can continue to support student growth in virtual environments.

Looking ahead, this research can be further investigated. As digital education continues to grow, the complexity and diversity of educational interactions will expand (Carroll, 2010; Dunn et al., 2012; Jensen & Peterson, 2022; Liyanawatta et al., 2022; Tzavara & Koufopoulos, 2021). The current methodology serves as a foundation for future research, offering the flexibility to adapt to new challenges and opportunities in the field of virtual drama education. The continued refinement of this approach promises to enhance the effectiveness of student group formation and the overall quality of digital theatre (or drama) education.

5. Conclusion

This study introduced and evaluated a novel CI-based methodology, using the Flying Foxes Optimization (FFO) algorithm, to form psychosocially homogeneous student groups in virtual drama education. The results demonstrated the method's effectiveness in creating balanced groups, optimizing collaboration, and enhancing creative outcomes. The ability to create group formation based on individual characteristics offers educators a useful tool to improve both pedagogical strategies and student experiences.

The accuracy and efficiency of FFO make it a useful tool. Its efficiency in handling large datasets, combined with its ease of implementation, ensures that it can be readily applied in diverse educational settings. This study not only highlights the practical benefits of CI in theatre education but also sets the groundwork for future research aimed at refining and expanding the use of such methodologies in virtual environments.

The findings highlight the capabilities of CI to transform group dynamics in educational contexts, particularly in digital theatre education. By promoting more cohesive and effective student collaborations, this approach holds promise for improving educational outcomes and supporting the development of critical skills in the digital age.

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