

From Personality to Performance: An Automated Grouping Tool for Collaborative Learning

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Abstract—As part of pre-service teacher training, this study presents a new web-based tool that intelligently groups learners based on their personality profiles (PCM, or Process Communication Model) to enhance collaborative work in flipped classrooms. The software automatically groups users by personality based on the results of a personality test. The application is compatible with all mobile devices and can be accessed through a web browser without the need for installation. The algorithm aims to improve role distribution, interpersonal communication, and conflict resolution by maximizing diversity within each group while taking contextual factors into account. Inspired by popular educational platforms like Kahoot, the user interface provides an intuitive experience for both teachers and students. Teachers can create classes, set group sizes, monitor results, and create ideal groupings with little work. A quasi-experimental pre-post implementation involving 267 trainee teachers, with a response rate of 63% (164 participants), revealed statistically significant improvements in collaboration and participant involvement following group reorganization through the application. These findings support the pedagogical relevance of integrating personality-based grouping technologies. They suggest that such technologies may foster learner engagement and self-awareness, and that they are associated with improved collaboration in educational environments. They suggest that such technologies may foster learner engagement, self-awareness, and effective collaboration in educational environments. The study contributes to the field by providing empirical evidence of the applicability of the PCM framework in teacher training contexts and by demonstrating the feasibility of integrating personality-based grouping mechanisms into digital learning environments.

Keywords—*Personality-based grouping; Process Communication Model (PCM); Computer-Supported Collaborative Learning (CSCL); team diversity; educational technology; teacher training; flipped classroom; collaborative learning*

I. INTRODUCTION

Any consideration aimed at sustainably improving the quality of education must take into account the early stages of schooling, particularly primary school. It is at this stage that fundamental learning processes, such as reading, writing, and structuring thought, begin decisively. These learning processes are rooted in a phase of intense cognitive development, particularly among children of the Alpha generation [1]. Their intellectual abilities, although comparable to or even superior to those of previous generations, are shaped by a world profoundly transformed by digital technology [2].

In this context, teachers play a fundamental role as mediators. It is therefore essential to strengthen their initial training by incorporating innovative teaching practices. These

practices should combine subject content with tools for analysing personality profiles. Such an approach aims to improve interpersonal communication, strengthen group cohesion and promote more effective collaborative learning environments.

Among these practices, the flipped classroom stands out as a benchmark model [3]. By redefining traditional roles, it promotes autonomy, cooperation and active engagement among learners [4]. Teachers in training thus experience complex collaborative situations. In these situations, communication skills play a central role [5]. This need for social skills is all the more crucial in the era of Industry 5.0 [6]. Emotional intelligence, collaboration and interaction management are becoming key elements of employability [7].

In this context, educational technologies are opening up new possibilities for optimizing the organization and effectiveness of collaborative work. The application tested in this study aims to automatically form balanced groups of trainee teachers. The grouping is based on personality profiles defined by the Process Communication Model (PCM) [8]. This model proposes a behavioural typology associated with different communication styles. It makes it possible to anticipate conflicts, facilitate exchanges and distribute responsibilities more coherently.

This research aims to evaluate the changes in collaborative interactions observed following the introduction of the application within a flipped classroom context. The study adopts a quasi-experimental pre-post design. It examines changes in communication quality, task coordination, involvement and conflict management, following personality-based group structuring grounded in the Process Communication Model (PCM), within the Moroccan teacher training context.

II. THEORETICAL FRAMEWORK AND METHODOLOGICAL CHOICES

A. Flipped Classroom and Acquisition of Collaborative Skills

Over the past decade, the flipped classroom model has undergone significant evolution, gradually establishing itself as an innovative teaching approach in several academic fields of specialization [9]. Based on the principle of disseminating content outside the classroom, this methodology promotes active learner engagement, the use of advanced digital resources, and the development of autonomy in research and information management.

By combining these tools with collaborative structuring of activities, learners not only strengthen their understanding of the subject matter, but also develop essential cross-disciplinary

skills such as project management, content creation, and peer collaboration.

Studies have shown that the flipped classroom is more effective than traditional approaches in secondary and higher education [10]. It promotes intrinsic motivation [11], self-efficacy, cooperation and critical thinking [12], contributing to improved overall performance and student engagement, including their problem-solving skills.

B. Limitations of Collaborative Work in Initial Training

Once the working groups have been formed, the trainer acts as a facilitator, encouraging cooperative interactions and high-quality interpersonal communication [13]. The ability to collaborate effectively is now an essential skill in professional environments, and acquiring it during initial training is a real challenge for future teachers [14].

However, several difficulties hinder the implementation of collaborative work: interpersonal conflicts, unequal distribution of tasks, delays in project delivery, or even unilateral completion of work [15]. These dysfunctions, frequently observed in the delivery of collective projects, seem to be largely linked to the formation of groups based on random or social criteria (personal affinities, geographical proximity, etc.). [16]

C. Interpersonal Communication: A Key Factor for Success

The success of collaborative projects depends heavily on the quality of communication. Clear, harmonizer and structured communication facilitates task distribution, time management and tension resolution, and has a direct impact on the quality of the work produced [17].

Several studies now advocate for the explicit integration of these skills into training frameworks, on a par with critical thinking, creativity, and teamwork [18].

D. Personality Profile and Communication Style

Each individual adopts a communication style influenced by their socio-cultural environment, personal history, and personality. The latter is a source of variability that can lead to misunderstandings or tensions, particularly in stressful situations or when time is limited.

In these contexts, it becomes relevant to use tools for analysing personality profiles and communication styles. Models such as MBTI, DISC, Big Five, and PCM are commonly used in professional, educational, and clinical settings to understand interpersonal dynamics and optimize team functioning.

In Table I, we have compared the four models in order to choose the one best suited to our study.

TABLE I. COMPARISON OF THE MAIN PERSONALITY MODELS

Mode l	Principle	Use	Main Focus
DISC [19]	Assesses behaviours according to four dimensions: Dominance, Influence, Steadiness, Compliance	Understanding leadership styles and interactions	Communication Behaviour

Mode l	Principle	Use	Main Focus
MBTI [20]	Classify individuals according to four axes: Extraversion/Introversion, Sensing/Intuition, Thinking/Feeling, and Judging/Perceiving.	Motivation and learning styles	Cognition Personality
Big Five OCEAN [21]	Unique profile based on 5 traits: Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism.	Personal guidance	Personality Traits
PCM [8]	6 personality types: Thinker, Persister, Harmonizer, Rebel, Promoter, and Imaginer, as well as the communication channels specific to each personality.	Stress prevention, interpersonal adaptation	Interpersonal Communication

E. Choice of PCM Model

In light of this comparison, the Process Communication Model (PCM) is particularly relevant due to its practical emphasis on real-time communication adaptation, conflict management, and stress regulation—key dimensions in collaborative educational settings such as the flipped classroom. Moreover, PCM provides structured and immediately applicable strategies for optimizing group dynamics and strengthening cohesion among learners with diverse personality profiles.

The model is characterized by its interactional focus [22], its empirical grounding across professional [23], educational, and medical contexts, and its capacity to enhance communication processes in real time. These characteristics support its integration into the present application for personality-based group allocation within the framework of this study.

The PCM identifies six personality types (Thinker, Promoter, Persister, Imaginer, Rebel and Harmonizer) [8], each associated with a dominant communication channel. It is designed to support interpersonal adaptation, enhance conflict management strategies, and improve the regulation of stress responses, as summarized in Table II.

TABLE II. THE SIX PERSONALITY TYPES IN THE PCM MODEL [8]

Personality Type	Characteristics	Communication Profile
Thinker	Logical, Thoughtful, Structured	Factual Communication
Promoter	Dynamic, Persuasive	Persuasive and Quick Communication
Persister	Practical, Methodical	Structured and Planned Communication
Imaginer	Introverted, Calm	Deep Communication
Rebel	Creative, Spontaneous	Playful and Humorous Communication
Harmonizer	Sensitive, Caring	Compassionate, Conscious, and Emotional Communication

F. Evidence of PCM Effectiveness

Studies conducted with surgeons trained in PCM have highlighted improved conflict management, reduced stress and a more harmonious working environment [24]. In addition, other research has established links between PCM profiles and certain cognitive or neuropsychological functions [25], suggesting a

growing scientific depth to the model. It should also be noted that certain PCM model profiles tend to promote the generation of creative ideas through their communication channels. This relationship between personality and creativity can be used to improve collaboration and stimulate innovation in groups [26].

III. OBJECTIVE OF THE STUDY

In this context, the objective of the research is to verify the hypothesis that integrating the PCM model into a flipped classroom system promotes collaboration and the quality of interactions between learners.

The main hypothesis posits that structuring groups based on personality profiles improves communication flow, task distribution and tension management within teaching teams. The next section presents the experimental protocol put in place to test this hypothesis.

IV. TECHNICAL ARCHITECTURE OF THE APPLICATION

A. System Architecture and Technical Framework

- **Back-end:** The application server is designed with Django, an open-source framework based on Python, which follows the MTV (Model-Template-View) architecture [27]. This choice is based on the maturity of the framework, its comprehensive documentation and its ability to accelerate development while ensuring good maintainability.
- **Front-end:** The user interface was created using the Bootstrap framework [28], enabling a responsive interface that is compatible with different screen formats (smartphones, tablets, computers).
- **Database:** The system is based on PostgreSQL [29], an RDBMS known for its reliability, performance, and seamless integration with Django. It manages user data, personality test results, and groups.
- **Messaging system:** Automatic email sending is managed via OAuth 2.0 authentication connected to the Gmail API, hosted on Google Cloud Platform. This solution avoids direct storage of login details. An alternative via SMTP can be considered for lighter environments.

B. User Interface Design

The application was designed with a user experience (UX) focus, with particular attention paid to ease of use and mobile accessibility. Inspired by tools such as Kahoot [30], the interface differentiates between the role of the trainer (session creator) and that of the participants.

No installation is required, and the application is fully accessible via a web browser. Data is stored in a PostgreSQL database and processed by an algorithm that automatically forms groups based on the results of the PCM test and additional academic criteria.

C. Justification of Technical and Ergonomic Choices

The choice of a web application that can be accessed without installation meets two objectives: to avoid saturating users' personal phones and to guarantee quick access from any device.

The Kahoot interface model [31] was chosen for its familiarity to teachers and its potential for engagement. Django and Python ensure reliable data management and good scalability. [32]

V. METHODOLOGY OF EXPERIMENTATION

A. Target Population for the Experiment

The study was conducted among trainee teachers undergoing initial teacher training. This decision was based on two complementary considerations.

On the one hand, these future teachers will be responsible for educating Generation Alpha, for whom soft skills – collaboration, communication, critical thinking and adaptability – are essential in the context of Industry 5.0. It is therefore important that the trainee teachers themselves master these skills so that they can pass them on effectively to their pupils.

On the other hand, the initial teacher training programme requires trainee teachers to work regularly in groups on projects. However, field observations reveal frequent problems in collaborative work: interpersonal conflicts, unequal distribution of tasks, delays or an excessive workload falling on a single group member. Improving the quality of their training therefore requires the creation of more productive and creative groups, which justifies the relevance of this target population.

These findings highlight the need to structure groups according to more robust educational criteria than personal or geographical affinities.

The experiment took place at the Regional Center for Education and Training Professions (CRMEF) [33] in Tetuán city, a public institution under the Ministry of National Education. This centre provides initial and continuing training for teachers and educational managers in the northern region of Morocco.

Table III shows the distribution of participants (trainee teachers) at the CRMEF in Tetuán city according to the educational level of the training, specialization and assignment group.

TABLE III. DISTRIBUTION OF TRAINEE TEACHERS BY SPECIALIZATION AND SCHOOL LEVEL ACCORDING TO THE CRMEF CENTER

Level	Speciality	Group No.	Number of trainee teachers	Having participated in the study
Primary	Arabic-French-Mathematics	1	34	✓
		2	34	✓
		3	34	✓
		4	34	✓
		5	34	
Middle school	History-Geography	1	26	✓
	Islamic education	1	45	✓
	Mathematics	1	30	✓
	Mathematics	2	30	
	French	1	30	✓

	Arabic	1	30	
	Life and Earth Sciences	1	30	
High school	Arabic	1	30	
Total		13	421	267

The study involved 267 trainee teachers from various subject areas, working in both primary and secondary schools, who are set to become the teachers of Generation Alpha (those born from 2012 onwards). This group was selected because of its relevance to the implementation of innovative teaching practices within the Moroccan school system.

B. Presentation of the Experimental Protocol

1) *Group formation algorithm*: The grouping algorithm operates by sequential allocation. Participants are first sorted by their dominant PCM type. They are then distributed across the predefined groups using a round-robin procedure, in which each participant is placed in the first available group that does not already contain a member of the same dominant type. This mechanism constitutes the implicit optimization objective of the algorithm: to maximize the variety of personality types within each group.

Formally, for each group G_j of size g , the algorithm seeks to maximize the Shannon diversity index $H(G_j)$, subject to the constraint $|G_j| = g$. When a participant's dominant type is already present in all available groups, the algorithm places the participant in the group where this type is least represented, thereby minimizing redundancy (Algorithm 1).

Algorithm 1: PCM-Based Balanced Group Assignment

```
Initialize:
    L ← list of all participants
    g ← desired group size (teacher-defined,  $2 \leq g \leq 20$ )
Compute:
    N ← |L|
    k ← ceil(N / g) // number of groups
    Initialize k empty groups G1, G2, ..., Gk
    For each participant i in L do
        Determine dominant PCM type P(i)
        Store P(i)
    End For
    Sort L by P(i) // group same types together
    index ← 0
    While (index < N) do
        For (j ← 1 to k) do
            if (index < N) then
                If (size(Gj) < g) then
```

```
                    Add L[index] to Gj
                    index ← index + 1
            End If
        End For
    End While
    For (each group Gj) do
        For (each participant in Gj) do
            Send email containing:
                - group number
                - members list
                - personality types
                - communication channels
        End For
    End For
```

In the current version, secondary personality characteristics are not explicitly weighted in the allocation decision. The algorithm relies solely on the dominant PCM type. The option to adjust weighting parameters, mentioned in the application interface, is designed for future iterations and was not activated in the present study. This distinction is important: the results reported here reflect the default allocation mechanism, without additional weighting.

2) *Workflow of the grouping process*: To facilitate overall understanding of the approach adopted, a summary diagram was designed (Fig. 1). It illustrates the key stages of the experiment, from the collection of personality data via the application to the reorganization of the groups and the post-experiment evaluation. As shown in the diagram, participants were first randomly divided into groups (the specific configuration of 6 groups of 5 members being merely one illustrative instance used in this study) and completed an initial collaborative project. They then used the PCM-based applications, which simultaneously:

- provided each participant with their group composition, the personality types present, and the associated communication channels;
- redistributed all participants into new groups balanced by personality type, using the round-robin algorithm; and
- delivered detailed information on the preferred communication channel corresponding to each personality type.

A second project, analogous to the first, was carried out in these newly formed groups. Finally, a questionnaire compared the trainee teachers' perception of communication quality before (pre-test) and after (post-test) the regrouping intervention.

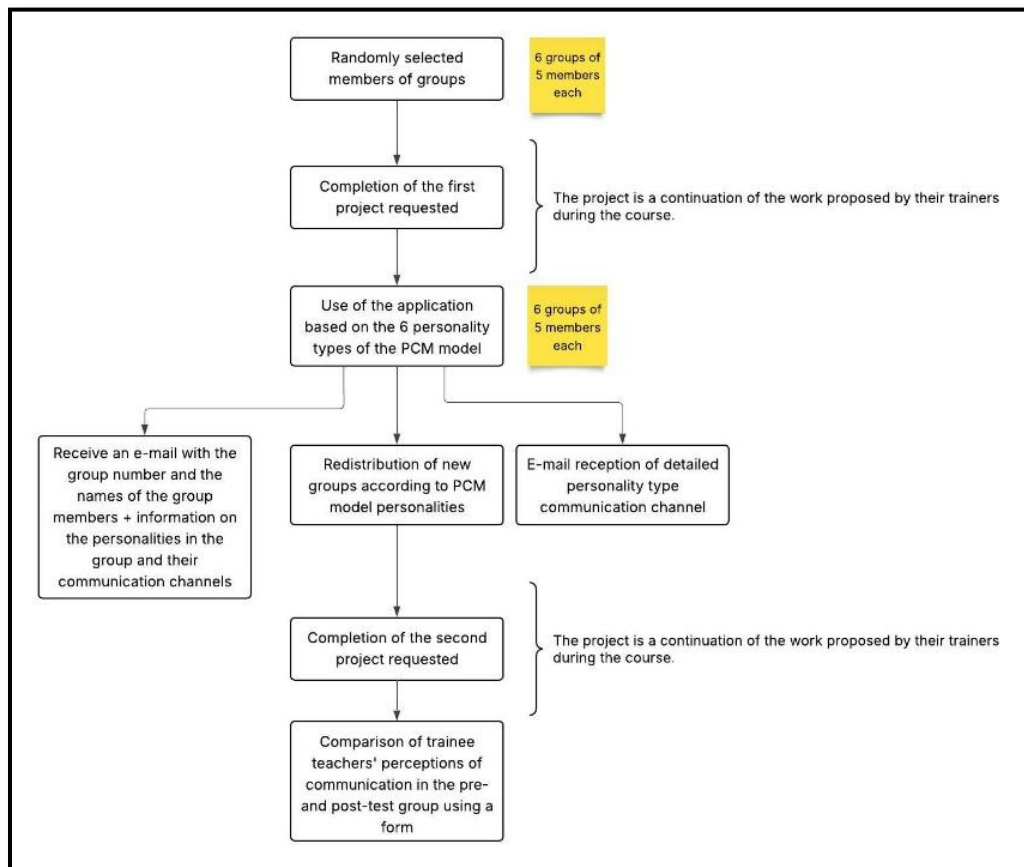


Fig. 1. Diagram of the experimental protocol for forming groups using the PCM model.

3) *Personality diversity representation*: To assess the balance of PCM personality types within each generated group, we employed the Shannon Diversity Index. This index was preferred to Simpson's index because it is more sensitive to rare personality types [34], which is essential to detect imbalance when a PCM type is underrepresented. According to [35], personality types constitute a "variety" diversity construct, for which entropy-based measures such as the Shannon index are particularly well suited. Moreover, its exponential yields an intuitive "effective number of types" [36], aligning well with the pedagogical interpretation of group composition.

Widely used to measure diversity in various disciplines, the Shannon index quantifies both the variety and evenness of personality types present in a group. It is calculated as follows:

$$H = - \sum_{i=1}^k p_i \log(p_i)$$

Where:

H represents the group diversity index.

k denotes the number of PCM personality types (k = 6 in this study).

log denotes the natural logarithm

pi is the proportion of personality type *i* within the group.

A higher H value indicates greater diversity. For a group of six members, the maximum diversity (H = 1.79) is achieved when all six PCM types are equally represented (one participant per type). The index was calculated for each group based on the final participant assignments.

C. Description of the Application Phases

The experiment is based on a web application designed specifically to enable the automated formation of educational groups, based on personality profiles defined by the Process Communication Model (PCM). To measure the effects of this tool on group dynamics, the study was structured in five successive phases, as follows:

1) *Phase 1: Completion of an initial collaborative project (random groups)*: Before using the application, participants were randomly divided into working groups based on attendance lists provided by the CRMEF Center Management. No specific criteria (profile, affinity, skills, etc.) were applied at this stage.

These groups were given a project to complete, linked to the educational modules of the training program, while adhering to the guidelines for quality of output and meeting deadlines.

The objective of this first phase is to serve as a reference for evaluating initial collaborative dynamics, without structuring based on personality profiles in a flipped classroom context.

2) *Phase 2: Using the PCM application to reconfigure groups*: After the initial experiment, participants in the experimental group were invited to use the experimental application. The app is called Talkflow, in reference to the ease of communication it facilitates thanks to this grouping based on personality types (Fig. 2).

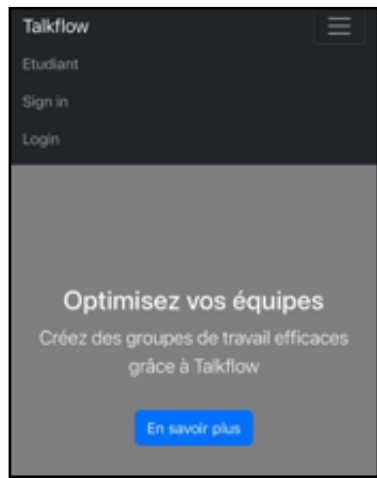


Fig. 2. The main interface of the Talkflow application.

This phase comprises several technical steps: The trainer creates an account on the application, then configures the session by entering the name of the class, the total number of learners, and the desired size of the subgroups.

The app then automatically checks the consistency of the settings entered (e.g., divisibility of the total number by the size of the groups) and suggests automatic adjustments in case of incompatibility.

This automation aims to ensure a balanced and consistent distribution, while avoiding the manual errors that are common when forming teaching groups (Fig. 3).



Fig. 3. View of the group creation screen as seen by the trainer.

3) *Phase 3: Taking the PCM test and automated group formation*

a) *Participant registration and class access*: Once the class settings have been validated (name, number of learners,

group size), the application automatically generates a unique access code. This code is sent by the trainer to the participants, who can then join the session via a responsive web interface (Fig. 4).

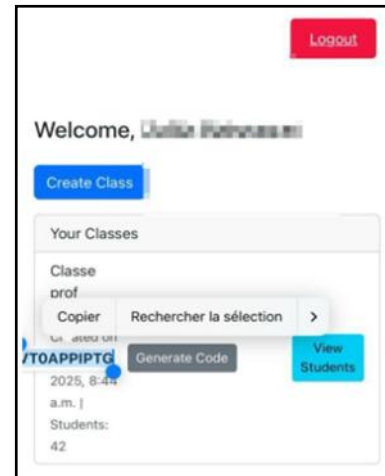


Fig. 4. View of the screen that allows you to generate a code for the class created by the trainer to share with participants.

Trainee teachers enter their personal details (surname, first name, email address) and the code provided, then access the personality test based on the Process Communication Model (PCM).

b) *Taking the PCM personality test*: The PCM assessment used in this study was adapted from a personality identification exercise introduced during a professional training session organized as part of the Integrated School Project (Projet d'Établissement Intégré, PEI). This project, implemented in Moroccan secondary schools, received support and funding from the Millennium Challenge Corporation (MCC) through the Compact II bilateral cooperation programme. The training programme covered several areas, including soft skills, communication and change management. Within the soft skills component, a personality identification exercise based on the Process Communication Model was introduced.

Participants were presented with a list of personality traits and asked to select, one by one, the traits that best corresponded to their typical behaviour. As soon as three traits belonging to the same PCM personality type were selected, that type was assigned to the base of the participant's personality triangle, reflecting its dominance. The exercise continued until all six PCM types had been positioned, from the most dominant at the base to the least dominant at the top.

During the training sessions, the participating teachers, including the first author, generally perceived the exercise as relevant and consistent with their self-perceived personality profiles. Although this perception does not constitute a formal validation, it suggests that the instrument was well received and considered meaningful by its users.

To our knowledge, this version of the questionnaire has not been formally validated for the Moroccan educational context.

The present study did not conduct an independent psychometric validation. Its aim was practical: to apply the PCM framework in a real teacher training setting and to observe its effects on group dynamics. The results should therefore be interpreted with this limitation in mind.

Once the test is completed, the application automatically generates a PCM personality triangle for each participant. This visual depiction makes interpretation easier and shows:

- The dominant personality (at the base)
- The secondary personalities (at the upper levels)
- The personality least represented in the profile (at the top)



Fig. 5. View of the screen (of the participant) showing their personality triangle according to the PCM test.

c) Group formation algorithm: As tests are received, the application automatically divides participants into balanced groups based on their PCM profile. The algorithm has been significantly enhanced to:

- Ensure, where possible, that each group contains several different personality types
- Avoid homogeneous groupings (e.g. several Promoter or Harmoniser profiles in the same group)
- Maximize the complementarity of profiles, thereby promoting rich and constructive interpersonal dynamics
- Allow teachers to adjust weighting parameters based on specific activity requirements

d) Communication of results and assignment to groups
Each participant automatically receives:

- Their PCM personality triangle (Fig. 5)
- The name of their assigned group

- The composition of their group (identity and PCM profile of members)
- An explanatory educational document presenting the six personality types, their preferred communication channels, and practical advice for harmonious interaction

On the trainer's side, a summary table of the groups is accessible from their personal space in the application. This table classifies learners according to their profile and assigned group, allowing for immediate educational follow-up.

#	Name	Email	Score
1		@etu.uae.ac.ma	imager
2		@gmail.com	thinker
3		@gmail.com	rebel
4		@gmail.com	harmonizer

Fig. 6. View of the screen (from the trainer) displaying the group number, members, and their personality profiles.

4) Phase 4: Completion of the second project in PCM groups: A new collaborative task, still related to the training program, is assigned to the groups reconfigured using the application, according to the groups displayed (Fig. 6). The instructions and assessment criteria remain unchanged to ensure the comparability of the two collaborative experiences (before and after using the PCM test). Participants are asked to produce a high-quality collective deliverable, in accordance with deadlines and educational standards.

5) Phase 5: Post-experiment evaluation: At the end of phase 4, participants complete a comparative evaluation questionnaire (pre/post-experiment). This questionnaire aims to gather information on:

- Feelings about group dynamics
- The fluidity of communication
- Task distribution
- Conflict management
- Overall quality of collaboration

The objective of this step is to evaluate the perceived impact of the application on collaborative dynamics, relational serenity and group productivity. The results allow us to examine the link between self-knowledge/knowledge of others and collective performance in a flipped learning environment.

D. Pre- and Post-experience Evaluation Form

The questionnaire was distributed digitally to all 267 participants who took part in the various phases of the project. Of these, 164 responded, representing a participation rate of 63%, with 161 usable responses. The improvement in response rate appears to be associated with the provision of immediate,

personalized feedback on individual personality profiles, which may have enhanced participant engagement and perceived relevance of the assessment.

E. Focus of the Questionnaire

The questionnaire aimed to assess several aspects of group dynamics before and after the experiment:

- The fluidity of exchanges
- The distribution of tasks
- Adherence to deadlines
- Conflict management
- Overall feelings (atmosphere, serenity, autonomy)
- Interest in the PCM model applied to the flipped classroom

VI. RESULTS

A. Personality Diversity Analysis

Table IV presents the Shannon Diversity Index calculated for each of the five groups formed by the algorithm for a class of 30 participants (group size = 6). The composition and diversity score for each group are detailed below.

TABLE IV. COMPARISON OF MEAN SCORES BEFORE AND AFTER THE INTERVENTION USING THE WILCOXON TEST AND EFFECT SIZES

Group	Size	Composition (PCM Types)	Shannon Index (H)
G1	6	Thinker, Promoter, Persister, Harmonizer, Rebel, Imaginer	1.79
G2	6	Rebel, Harmonizer, Thinker, Persister, Imaginer, Promoter	1.79
G3	6	Thinker, Promoter, Persister, Harmonizer, Rebel, Imaginer	1.79
G4	6	Harmonizer, Rebel, Thinker, Persister, Thinker, Imaginer	1.56
G5	6	Harmonizer, Rebel, Thinker, Harmonizer, Harmonizer, Harmonizer	0.87
Mean (SD)			1.60 (0.34)

The analysis shows that three groups (G1, G2, and G3) achieved the maximum diversity score ($H = 1.79$), indicating perfectly balanced representation where all six PCM personality types were present exactly once. Group G4 also demonstrated a high level of diversity ($H = 1.56$), despite containing two Thinkers. However, Group G5 exhibited a lower diversity index ($H = 0.87$) due to the over-representation of the Harmonizer type (four out of six members).

B. Pre Post Intervention Results

To assess the evolution of collaborative dynamics after group reorganization, we compared the pre- and post-intervention questionnaire scores based on 161 usable responses. Given the ordinal nature of the data and the paired design, a non-parametric Wilcoxon signed-rank test was used.

Table V summarizes the results, including mean scores, p-values, and effect sizes.

TABLE V. PRE- AND POST-INTERVENTION COMPARISON

Variable	Before Mean (SD)	After Mean (SD)	p-value (Wilcoxon)	Cohen's d	Effect Size
Collaboration	2.35 (1.00)	3.33 (1.29)	< 0.001	0.58	Moderate
Implication	3.25 (0.90)	3.78 (1.08)	< 0.001	0.41	Moderate
Communication	3.37 (0.99)	3.28 (1.36)	0.548	-0.05	Negligible
Conflicts	3.47 (1.24)	3.58 (1.21)	0.511	0.06	Negligible

Note: p-values from Wilcoxon signed-rank test for paired samples; Cohen's d calculated for paired samples.

C. Qualitative Results

The open-ended responses collected provided additional insight into individual perceptions of collaboration within groups, before and after their reconfiguration based on PCM profiles.

Regarding situations of non-investment or failure to meet deadlines by a group member, several participants expressed recurring feelings of frustration, demotivation, and even conflict avoidance. Some stated that they 'preferred to take on the entire task,' while others indicated that they 'no longer intervened when a member failed to contribute,' highlighting passive emotional management and an imbalance in the distribution of work.

About spontaneously adopted roles, the responses revealed recurring functions such as coordinator, planner, executor or mood regulator. The notion of explicit leadership, on the other hand, was rarely mentioned, which could reflect a horizontal work dynamic or a lack of structure in the initial groups.

Finally, feedback on the PCM model trial was overwhelmingly positive. Many participants reported improved communication, better mutual understanding, smoother coordination, a more balanced distribution of responsibilities and a more relaxed working atmosphere.

Illustrative excerpts:

- We understood each other better in the second group.'
- Everyone knew what to do; it was more fluid.'
- The test helped me understand why some people react that way.'

- The atmosphere was better; there wasn't the same tension as during the second project. '

VII. DISCUSSION

A. Interpretation of Personality Diversity Results

The results demonstrate that the automatic group formation algorithm is largely effective in creating diverse personality profiles within groups. The fact that three out of five groups achieved perfect balance ($H = 1.79$) confirms that the algorithm's core mechanism—avoiding repetition of personality types within a group—can successfully produce optimally diverse teams under typical participant flow conditions. This result aligns with the principles of variety-based diversity, which emphasize that teams benefit from a mix of different categories rather than from separation or disparity alone [35].

The lower diversity score observed in Group G5 provides valuable insight into the algorithm's current limitations. This imbalance occurred because multiple participants with the Harmonizer personality joined the application consecutively during the later stage of the group formation process. When the first Harmonizer was assigned to G5, it was the only personality type missing from that group. However, as subsequent Harmonizers enrolled, the algorithm had no mechanism to distribute them to other groups, as all other groups had already reached the maximum size ($n = 6$) set by the instructor. This reveals a key area for future improvement: implementing a predictive or queue-based mechanism that reserves slots for underrepresented personality types, particularly towards the end of the enrolment process.

It is important to note that the system is designed to accommodate various group sizes (e.g., 3, 4, 5, or more members) according to the instructor's preferences. The underlying principle of balancing personality types remains applicable regardless of group size, although the maximum achievable diversity score will vary accordingly. Future work will explore the algorithm's performance across different group sizes and participant enrolment sequences, and will investigate optimized assignment strategies to further minimize imbalances such as the one observed in Group G5.

B. Interpretation of Pre-Post Intervention Results

The pre- and post-intervention analysis revealed significant improvements in several dimensions of collaborative work following the reorganization of groups based on PCM personality profiles. Table V presents the descriptive statistics and comparative analysis.

Collaboration showed a statistically significant increase ($p < 0.001$, Wilcoxon signed-rank test). The mean score rose from 2.35 ($SD = 1.00$) before the intervention to 3.33 ($SD = 1.29$) after. The effect size (Cohen's $d = 0.58$) indicates a moderate to large effect. This suggests that personality-based group formation was associated with a meaningful increase in participants' perceived quality of collaboration. This finding aligns with the qualitative feedback, where participants reported smoother coordination and a more balanced distribution of responsibilities in the reconfigured groups. This improvement is consistent with studies suggesting that group composition based

on interpersonal variables may enhance cooperative processes [7], [14].

Implication (participant involvement) also increased significantly, with mean scores rising from 3.25 ($SD = 0.90$) to 3.78 ($SD = 1.08$). The effect size (Cohen's $d = 0.41$) represents a moderate effect. This improvement is particularly noteworthy. Although some participants who were highly involved in their original groups reported initial disruption, overall involvement increased across the sample after the reorganization. This suggests that while some well-integrated individuals may have experienced initial disruption, the new group configuration ultimately fostered greater engagement for the majority of participants. This temporary disruption echoes findings that restructuring groups can initially unsettle established dynamics [16].

Communication remained stable, with mean scores of 3.37 ($SD = 0.99$) before and 3.28 ($SD = 1.36$) after the intervention. The difference was not statistically significant ($p = 0.55$), and the effect size was negligible ($d = -0.05$). This stability is consistent with the qualitative findings, where participants reported that communication improved for many, but the quantitative data suggests that overall, communication levels were already relatively well established and did not change substantially as a result of the intervention. This stability is in line with research showing that communication patterns are deeply rooted and may require longer interventions to evolve significantly [14], [17].

Conflicts showed a slight increase, with mean scores rising from 3.47 ($SD = 1.24$) to 3.58 ($SD = 1.21$). However, this change was not statistically significant ($p = 0.51$), and the effect size was negligible ($d = 0.06$). The qualitative results present an interesting contrast: many participants reported a "more relaxed working atmosphere" and "no tension like in the first project" after the reorganization. This discrepancy may indicate a change in conflicts, even if their frequency did not decrease. Conflicts may have become less disruptive or more manageable. Alternatively, the quantitative measure of conflict may not have fully captured the qualitative improvements reported by participants. This interpretation is supported by previous PCM studies reporting improved conflict management and a more harmonious environment following PCM training [24].

C. Interpretation of Qualitative Results

The qualitative analysis provided valuable insights that complement and enrich the quantitative findings.

- Perceptions of non-investment and workload imbalance: Participants reported recurring feelings of frustration, demotivation, and conflict avoidance when faced with group members who failed to contribute. Statements such as "I preferred to take on the entire task" and "I no longer intervened when a member failed to contribute" reveal passive emotional management strategies and highlight the importance of balanced workload distribution in collaborative settings. This finding suggests that participants who previously carried a heavier workload appreciated the redistribution of responsibilities in the reconfigured groups. These experiences of frustration and workload imbalance

mirror known challenges in unstructured group work [15].

- Spontaneous roles and leadership dynamics: The emergence of recurring roles such as coordinator, planner, executor, and mood regulator indicates that informal role distribution occurred naturally within groups. The rare mention of explicit leadership may reflect either a horizontal work dynamic or a lack of structural clarity in the initial groups. This finding suggests that personality-based group formation could potentially support more explicit role distribution, an avenue worth exploring in future iterations of the system. The spontaneous emergence of roles is a classic phenomenon in group dynamics [13], and our results suggest that personality-based grouping could formalize these roles more effectively.
- Positive reception of the PCM approach: The overwhelmingly positive feedback on the PCM model trial is particularly noteworthy. Participants reported improved communication, better mutual understanding, smoother coordination, more balanced responsibility distribution, and a more relaxed working atmosphere. Illustrative excerpts such as "We understood each other better in the second group" and "The test helped me understand why some people react that way" suggest that the PCM framework provided participants with a shared language to understand interpersonal differences. This metacognitive awareness may explain the observed improvements in collaboration and involvement. The positive reception of the PCM model is consistent with research demonstrating its benefits for communication and stress regulation in professional settings [23], [24].
- Complementarity with quantitative findings: The qualitative feedback helps explain the apparent discrepancy between the quantitative conflict measure (which showed a non-significant increase) and participants' reported perception of a "more relaxed atmosphere." [24] It is possible that while conflicts did not decrease in frequency, their intensity or disruptiveness diminished as participants better understood each other's communication styles. This interpretation is supported by statements such as "there was no tension like in the first project," suggesting that conflicts, when they occurred, may have been less emotionally charged or more easily resolved.

D. Key Findings

This study extends previous work on PCM in educational contexts [23], [24], [25], and it yielded several key findings regarding the effectiveness of PCM-based group formation on collaborative dynamics in teacher training contexts.

First, the Shannon Diversity Index analysis demonstrated that the proposed algorithm successfully created balanced personality profiles in three out of five groups (60%), achieving maximum diversity ($H = 1.79$). However, the algorithm's limitation in handling consecutive enrolments of the same

personality type was also identified, highlighting an area for future improvement.

Second, the pre-post intervention analysis revealed significant improvements in collaboration ($d = 0.58$, $p < 0.001$) and participant involvement ($d = 0.41$, $p < 0.001$) following group reorganization. These findings suggest that personality-based group formation is associated with increased engagement and cooperative behaviour among trainee teachers.

Thirdly, communication levels remained stable throughout the intervention, suggesting that the reorganization did not disrupt existing communication practices. This stability can be explained by the fact that the intervention took place during the second half of the academic year, a period by which the participants had already developed and established their communication patterns.

Fourth, while perceived conflict levels showed a slight non-significant increase, qualitative feedback revealed that participants perceived a "more relaxed working atmosphere" and "no tension like in the first project" after the reorganization. This apparent discrepancy suggests that the nature of conflicts may have changed, becoming less disruptive or more manageable, even if overall conflict frequency did not decrease.

Overall, these findings support the potential of personality-informed group structuring as a strategy to enhance collaborative learning environments in teacher training contexts, while also identifying clear directions for algorithmic refinement and future research.

E. Theoretical Contributions

This research contributes to the literature on collaborative learning and personality-informed educational technologies in several ways.

First, it provides empirical evidence supporting the relevance of the Process Communication Model (PCM) for understanding collaborative dynamics in teacher training contexts. The results suggest that personality-aware group structuring may positively influence collaboration, involvement, and conflict management among trainee teachers.

Second, the study demonstrates how personality-based grouping principles can be operationalized through a digital tool designed to automatically generate complementary working groups based on PCM personality profiles. This contributes to bridging the gap between personality theory and its practical implementation in educational settings.

Third, the research highlights the potential of pre-post experimental designs for evaluating the impact of collaborative learning interventions in authentic training environments. By examining the evolution of group dynamics before and after the intervention, the study provides methodological insights for future research on technology-supported collaborative learning.

Finally, the study contributes to the growing body of research exploring how educational technologies can support the development of interpersonal and collaborative competencies that are increasingly required in modern educational systems.

F. Practical Implications

The findings of this study provide several practical implications for teacher training programs and educational practitioners.

For educators and instructional designers, the results suggest that personality-based group formation can support more balanced and effective collaborative work. By considering differences in communication styles and personality structures, teachers may facilitate better interaction, clearer task distribution, and improved group cohesion during collaborative learning activities.

The web-based application developed in this research illustrates how digital tools can assist educators in organizing collaborative learning environments more efficiently. By automatically generating complementary groups based on PCM personality profiles, the tool reduces the complexity of manual group formation while encouraging diversity within teams.

For teacher training institutions, the results highlight the potential value of integrating personality-awareness approaches into training programs. Helping trainee teachers better understand their own communication styles and those of others may contribute to improving collaboration, conflict management, and interpersonal adaptability in professional practice.

Finally, the results suggest that personality-informed grouping strategies may support the development of collaborative and socio-emotional competencies that are increasingly important in modern educational systems.

G. Limitations and Future Research

Despite the promising results of this study, several limitations should be acknowledged.

First, the sample was limited to trainee teachers from a specific geographical region in northern Morocco, which may limit the generalizability of the findings to other educational contexts. Second, the duration of the study was restricted to a single academic term, which does not allow for the observation of long-term effects of personality-based group formation on collaborative learning dynamics.

Third, some of the measures used in the evaluation rely on self-reported perceptions, which may be influenced by social desirability bias.

Fourth, the intervention comprised several simultaneous components: PCM personality feedback, explanation of communication channels, disclosure of group members' personality profiles, group reassignment, and participation in a second collaborative task. This design does not allow the observed improvements to be attributed to any single component. The changes may reflect the personality-based grouping algorithm, increased awareness of communication styles, the novelty of the digital application, or simply the effect of changing group membership. Future research should isolate these components, for example by comparing groups that receive different combinations of feedback, regrouping, and instructional explanation.

Fifth, the overall response rate was 63% (164 of 267 participants). The final questionnaire was administered online, and non-response appears to reflect voluntary non-completion rather than any systematic exclusion. Because data on non-respondents were not collected beyond their initial participation, a formal comparison between respondents and non-respondents could not be conducted. It is therefore possible that participants who completed the final questionnaire differed from those who did not, for example in terms of motivation, engagement or satisfaction with the regrouping. This limitation should be considered when interpreting the findings.

Future research could address these limitations by expanding the study to larger and more diverse populations across different educational levels and institutional contexts. Longitudinal studies would also provide valuable insights into the sustainability of the observed improvements in collaboration and group dynamics.

From a technological perspective, several extensions of the system could be explored. Future work may include the integration of the application with existing Learning Management Systems (LMS), such as Moodle, through standards such as Learning Tools Interoperability (LTI), enabling seamless adoption within institutional digital learning environments.

Additionally, further development of the grouping algorithm could incorporate adjustable weighting parameters that allow educators to balance different grouping criteria depending on pedagogical objectives.

Finally, within the context studied, the results suggest that personality-informed grouping strategies may support the development of collaborative and socio-emotional competencies among trainee teachers.

VIII. CONCLUSION

This study explored the potential of personality-based grouping to enhance collaborative learning in teacher training contexts. By combining the Process Communication Model (PCM) with a web-based application designed to generate complementary groups, the research examined how personality-informed group formation may influence collaborative dynamics among trainee teachers.

The results of the pre-post evaluation suggest improvements in collaboration and participant involvement within groups. While the quantitative measure of conflict did not show a statistically significant change, participants' qualitative feedback described a more relaxed working atmosphere and more manageable tensions. These findings indicate that increased awareness of personality differences, combined with structured group composition, may contribute to more effective collaboration and engagement in learning environments.

Beyond its immediate pedagogical implications, this research highlights the relevance of integrating personality-based approaches into digital educational tools. The proposed application demonstrates the feasibility of supporting group formation through simple and accessible technologies, offering educators practical support for organizing collaborative activities.

In the broader context of preparing future teachers to educate Generation Alpha in an era shaped by digital transformation and Industry 5.0, developing collaborative competencies and interpersonal awareness becomes increasingly important. By exploring the integration of personality-informed grouping within educational technologies, this research contributes to ongoing efforts to enhance collaborative learning practices in teacher training. The proposed application could also be considered for professional environments. However, this possibility remains exploratory, as the present study was conducted in a single teacher training institution. Future research would be needed to examine whether the observed benefits extend to other settings.

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