

Investigating group formation: An experiment on the distribution of extraversion in educational settings

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ABSTRACT

Group formation plays a crucial role in enhancing collaborative learning experiences. This study investigates the impact of extraversion as a criterion for group formation on collaborative learning outcomes. A total of 180 students participated in the experiment and were assigned to groups that were homogeneously or heterogeneously distributed in terms of extraversion. The groups met weekly and worked on group assignments throughout the semesters. The first hypothesis posed the outcomes to be explainable at the group-level. Surprisingly, the results show that groups with a homogeneous distribution of extraversion reported higher levels of group work satisfaction than those with a heterogeneous distribution, in contrast to the second hypothesis and the group hierarchy theory. These findings emphasize the potential of considering personality traits when forming groups and extend the existing literature on group formation. The study takes a critical stance by addressing normative definitions of leadership. Future research is suggested to further enhance collaborative learning experiences using similar interdisciplinary and experimental methods.

1. Introduction

1.1. Group work in higher education settings

Group work and collaborative learning significantly enhance student learning, motivation, and satisfaction in higher education (Blasco-Arcas et al., 2013; Johnson et al., 1991; Magnisalis et al., 2011; Ryan & Patrick, 2001). However, challenges like uneven workload distribution, poor communication, and low attendance can lead to potential group failure (Chang & Brickman, 2018; Hall & Buzwell, 2013; Rummel & Spada, 2005). Group formation has emerged as a potential solution to address these challenges equally for all students (Amara et al., 2016; Kozlowski & Bell, 2013; Srba & Bielikova, 2015).

The process of group formation, involving the selection and organization of individuals into groups, is crucial for fostering effective group experiences (Borges et al., 2018). Ensuring equal and successful group learning among students necessitates the design of effective group formation approaches (Damşa, 2014; Fazal-e-Hasan et al., 2021). Various methodologies have been investigated, ranging from computer-assisted learner group formation (Bekele & Menzel, 2005) to sophisticated

algorithms like genetic algorithms (Zheng et al., 2018) and multi-objective ant colony systems (Fahmi & Nurjanah, 2018).

Our study aims to contribute to the ongoing discourse on systematic group formation for improved learning outcomes, building upon prior research implementing group formation algorithms (Barkley et al., 2014; Müller et al., 2022; Revelo-Sánchez et al., 2021; Zheng et al., 2018). Emphasizing individual differences, particularly personality traits such as extraversion, we investigate the impact of algorithmic group formation based on variations in extraversion levels among group members—whether similar or different—on outcomes in student group work. Our objective is to provide insights into how algorithmic group formation based on variations in extraversion affects group experiences, to contribute to a deeper understanding of how the specific combination of individual traits within groups influences collaborative dynamics.

1.2. Unveiling the impact of group formation: distinguishing group-level and individual-level factors

Understanding how group- and individual-level factors interact is crucial for comprehending group behavior and implementing effective

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interventions (Kozlowski & Bell, 2013). Identifying whether group formation independently shapes outcomes or if individual traits wield greater influence is fundamental in perfecting group formation techniques (Hitt et al., 2007). The intricate relationship between individual traits and their impact within groups significantly shapes group dynamics and eventual outcomes (Blanco-Fernández et al., 2023).

Multilevel data structures pose challenges in capturing contextual features encompassing both individual characteristics and their surrounding contexts. While conventional analyses often focus on individually-measured outcomes (Hedeker et al., 1994; Raudenbush & Bryk, 2002), the composition of trait expressions within groups profoundly influences group dynamics and outcomes (Blanco-Fernández et al., 2023). This emphasizes the significance of recognizing both contextual and individual influences on group outcomes (LePine et al., 2011).

Previous studies highlight the impact of group-level factors on decision-making, problem-solving, creativity, and communication patterns, all significantly influencing group performance (Gawande et al., 2003; Loignon et al., 2018; Mannix & Neale, 2016; van Knippenberg & Schippers, 2007; Voltmer et al., 2022; Zennouche et al., 2014). These factors intricately link with individual personality traits, underscoring the need to consider these traits when forming groups (Maqtary et al., 2019; Moynihan & Peterson, 2001; Yannibelli & Amandi, 2011).

The complex interrelationship between individual and group levels of extraversion warrants deeper exploration to understand how an individual's traits are influenced within the broader group context. Investigating the interaction between levels of extraversion within and between groups holds promise in offering invaluable insights into optimizing group dynamics and enhancing outcomes.

1.3. The distribution of personality traits applied as group formation criteria

The widely used "Big Five" framework effectively measured and described personality traits (Hough & Oswald, 2000, 2005), yet inconsistencies persist regarding its role in group formation (Bell, 2007; Driskell et al., 2006; Lykourantzou et al., 2016).

The distribution of traits within groups prompts critical questions about optimal trait compositions, rooted in the person-environment (P-E) fit literature. This framework suggests that, depending on the trait, dissimilar traits may offer or reduced opportunities within groups (Tett & Christiansen, 2007; Tett & Guterman, 2000). Understanding trait distribution is pivotal for discerning the relevance of homogeneous or heterogeneous group fit hypothesis (Cable & Edwards, 2004; De Dreu & Weingart, 2003; Jackson et al., 2019). Diverse group members positively influence outcomes enabled by complementary skills, fostering interaction (Bekele & Menzel, 2005; Moreno et al., 2012; Seong & Hong, 2020; van Dijk et al., 2017). Conversely, homogeneous groups may foster better learning experiences (Den Hartog et al., 2019; Wilson et al., 2016). However, the prevalent formation of heterogeneous groups (84 primary studies (Borges et al., 2018)) has resulted in inconclusive or incomplete conclusions regarding trait distributions. Homogeneous fit, mostly used as a baseline, compromises the investigation of its independent effects (Apfelbaum et al., 2014).

1.3.1. Group formation using the distribution of extraversion

Individual extraversion significantly shapes behaviors and responses in social contexts (Huang & Wu, 2020), relating to positive feelings and impacts social interactions and organizational citizenship behavior within groups (Wilt et al., 2012; Moon et al., 2008; Mattila et al., 2011). Additionally, extraversion aligns with social network size, cognitive performance, and emotional experiences at an individual level (Pollet et al., 2011; LeMonda et al., 2015; Longua et al., 2009). Extraversion significantly shapes group dynamics, influencing social interactions and the establishment of hierarchical or non-hierarchical group structures (Taggar et al., 2006; Wilmot et al., 2019). Literature on group formation

underscores the profound impact of extraversion levels among group members on group functioning (McCabe & Fleeson, 2012; Wilmot et al., 2019). Higher levels of individual extraversion correlate with leadership behaviors such as initiating discussions and offering support to other group members (Judge et al., 2002; Porter et al., 2003). In hierarchical group structures, a leader with high extraversion typically leads while others assume follower roles, highlighting the role of extraversion in establishing group hierarchies (Kramer et al., 2014). Moreover, the intricate relationship between group extraversion and effectiveness is intertwined with communication patterns and leadership behaviors (Rothstein & Goffin, 2006). The effect of extraversion distribution on group outcomes remains a subject of debate. While some studies advocate for the benefits of heterogeneous extraversion distribution (French & Kottke, 2013; Humphrey et al., 2007, 2011) in enhancing student performance, others propose the superiority of homogeneous distribution for outcomes like innovative thinking and negotiation (Den Hartog et al., 2019; Wilson et al., 2016). However, limited research has experimentally investigated the impact of trait distribution on group formation outcomes (Borges et al., 2018). Exploring hierarchical group structures reveals their varied impact on group effectiveness. Stable hierarchies foster cooperative communication, role clarity, and facilitate decision-making (Ronay et al., 2012; Woolley et al., 2022). Conversely, unstable hierarchies, membership instability, and skill differentiation can lead to disruptive communication patterns and conflicts, detrimentally affecting group performance (Greer et al., 2018; Woolley et al., 2022). The lack of clarity in this area necessitates further research to better understand the role of extraversion distribution in diverse outcomes. The dominance complementarity theory, emphasizing balanced dominance, assertiveness, compliance, and submissiveness (Kiesler, 1983), aligns with extraversion's ability to enhance social experiences. This may elucidate why extraverts experience greater subjective well-being, leisure satisfaction, and happiness (Harris et al., 2017; Lu & Hu, 2005). Extraversion's positive aspects, like sociability, and assertiveness, contribute to the emergence of transformational leaders (Bono & Judge, 2004). However, while extraverted leadership might enhance group performance in passive situations, it might have counterproductive effects in proactive group settings (Tiedens & Fragale, 2003).

1.4. Research questions: group formation research and the role of extraversion

To address previous inconsistencies in the literature and gain deeper insights (Maqtary et al., 2019; Odo et al., 2019), we employ an experimental design using an algorithm for group formation that manipulates individual differences in extraversion. Here, the distribution of extraversion within groups can be conceptualized as a group characteristic with either homogeneously or heterogeneously appearance (Deckers et al., 2020, 2021). This approach enables more reliable conclusions about the causal relationship between group formation and the variables of interest. The influence of extraversion operates differently at individual and group levels, creating a complex interplay (Turban et al., 2009). Extraversion's influence on positive affect at the individual level is firmly established (Wilt et al., 2012). However, the group level significantly shapes this relationship, impacting sociable behavior within a group context (Moon et al., 2008; Mattila et al., 2011). The distribution of extraversion within a group influences the emergence of leaders and high-status individuals within these groups (Alam, 2022).

Furthermore, the collective level of extraversion within a group impacts group satisfaction and political participation, reflecting the intricate influence of other extraverts within the group (French & Kottke, 2013; Huber et al., 2021). Studies have indicated potential advantages in both heterogeneous and homogeneous distributions of extraversion (Den Hartog et al., 2019; French & Kottke, 2013; Humphrey et al., 2007, 2011; Wilson et al., 2016). However, each distribution model presents unique advantages and challenges. While heterogeneous distributions might facilitate task delegation and conflict management

(Humphrey et al., 2007; Tekleab & Quigley, 2014), homogeneous distributions could foster innovation and negotiation skills (Den Hartog et al., 2019; Wilson et al., 2016). Additionally, while research has predominantly focused on performance as the primary outcome of group work, it is imperative to expand our scope to include other relevant measures (Cachia et al., 2018; Rogat et al., 2022).

Our research addresses these gaps by experimentally manipulating extraversion in groups, thereby providing robust evidence to understand the causal relationships between member extraversion on outcomes. We explore whether various group outcomes are shaped by the interplay among members' constellations as a collective dynamic rather than solely by their individual attributes (Hitt et al., 2007; Kozlowski & Bell, 2013). Moreover, we anticipate that groups with algorithmically established mixed distributions of extraversion will demonstrate superior collaborative dynamics when compared to those with similar distributions. **Hypothesis 1** is as follow:

H1. Group-level characteristics, particularly the distribution of extraversion within groups, will significantly influence satisfaction (a), time investment (b), and performance (c) outcomes compared to individual-level factors.

As second hypothesis posed, we further anticipate that groups with algorithmically established mixed distributions of extraversion are expected to positively contribute to collaborative dynamics. **Hypothesis 2** states:

H2. Groups with a mixed (heterogeneous) distributions of extraversion are expected to be superior concerning satisfaction (a), time investment (b), and performance (c) outcomes, compared to groups with a similar (homogeneous) distribution.

2. Methods and materials

2.1. Sample and design

An experimental study design with one factor (extraversion) was manipulated into two conditions (homogeneous and heterogeneous) across students and courses. The total sample included 180 teacher-education students (female $n = 115$; Age $M = 22.2$, $SD = 1.65$) from a German university, all of whom had participated in the seminar as part of an academic module. The seminars were arranged in six courses, each with approximately 30 participating students.

In the initial survey, which was conducted before the formation of the experimental groups, demographic data of the participants, such as age and gender, as well as all personality traits and group orientation, were collected to identify possible differences between the experimental

groups before the study onset. Once informed consent and the initial survey were completed by all participants within each course, the algorithm GroupAL initially formed groups of three, for a total of 60 groups, of which members of 30 groups were homogeneously distributed and members of the other 30 groups were heterogeneously distributed in extraversion. After the algorithm GroupAL formed the groups, we informed the students about their group membership and instructed them to sit and work together throughout the entire term. Course meetings were conducted weekly. In addition, group assignments were constructed to stimulate group work and turned in weekly. During the course of the study, the outcome variables were regularly recorded in four evaluation surveys. To provide a comprehensive overview of the research method and process of the study, the study's timeline is displayed in Fig. 1.

2.2. Group formation algorithm to obtain experimentally distributed groups

The university where we conducted this study utilized Moodle's online learning management system (LMS). To support the formation of learning groups, we developed a Moodle plugin called MoodlePeers. This plugin provides a user interface for teachers to set up group formation within a course, as well as the administration of questionnaires and an overview of the status of group formation (e.g., not yet started, open for answers, and groups formed). In addition, the plugin includes an implementation of the optimization algorithm GroupAL. The algorithm GroupAL was used to determine how to group the participants and apply a different set of matching criteria to each part. By minimizing (or maximizing) the distance between all three group members simultaneously, it maintains the same fitness level (i.e., prior knowledge and motivation) in the matched overall groups (Konert et al., 2016).

2.2.1. Experimentally distributed groups

The research interest here lies in how the variance in extraversion [or other traits] within a group, as well as between different groups, influences group dynamics and outcomes. To investigate the role of group formation by extraversion, we carefully designed two types of experimental groups by the trait expression of extraversion: homogeneous and heterogeneous. This study design enables us to investigate the significance of both the overall formation of the group and within each group (Bellhäuser et al., 2018; Müller et al., 2022).

2.2.1.1. Homogeneous groups. Homogeneous groups comprised members with similar extraversion levels, providing an appearance of uniformity. In other words, they display comparable behaviors and tendencies related to extraversion, such as the need for social contact,

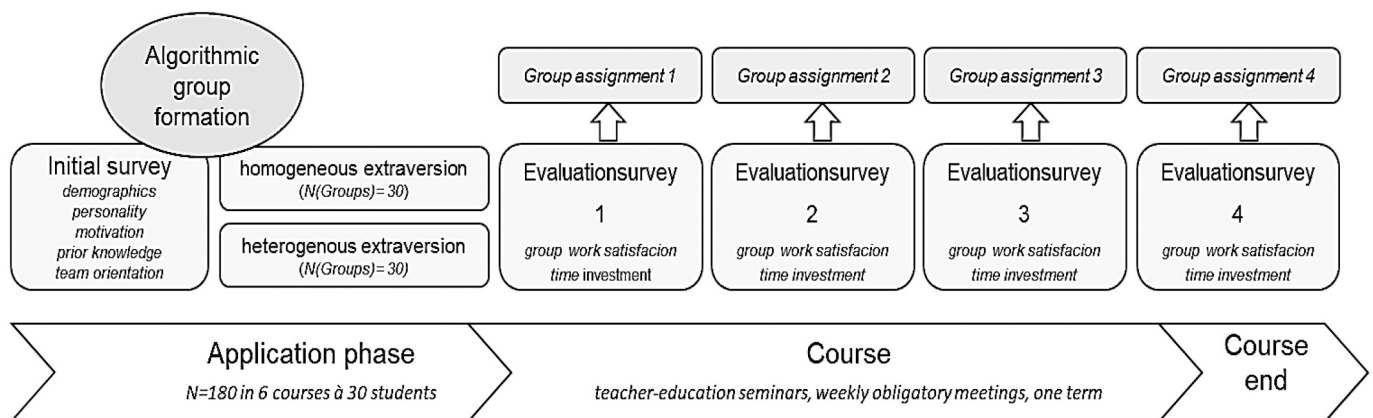


Fig. 1. Study timeline.

Note. Study Process divided in the three phases: Application Phase (initial survey, algorithmic group formation, established groups), the course (with evaluations 1–4, group assignments 1–4), and end of the course after one term.

communication, and the desire to engage in conversation (AbuSeileek, 2007, 2012; Barrick & Mount, 1991). Methodologically, for homogeneous groups, the algorithm aimed to maximize the similarity among their members in terms of extraversion, while still ensuring variation in the trait levels among different homogeneous groups. Consequently, even if the persons within these groups can be classified as similar at first glance due to the names of these groups, they encompass a wide spectrum of extraversion levels, including high, medium, and low expressions, depending on the sample's trait values, such as range and mean. This approach allows us to assess the similarity (homophily) between group members, not their absolute levels of trait expression.

2.2.1.2. Heterogeneous groups. In a heterogeneous group, each member exhibits a different level of extraversion, ranging from high to low expression. The algorithm strives to create a high standard deviation in this trait within the group, indicating the significant differences in the level of extraversion between members of the same group. In contrast to homogeneous groups, where the algorithm maintains a high standard deviation between the groups by keeping trait expression consistent within each group.

For homogeneous groups, the algorithm aimed to create maximum similarity among members concerning extraversion, while ensuring diversity in expression levels. In contrast, heterogeneous groups were designed to have the same mean extraversion level but significant variations within the group. This method was aimed at evaluating the effect of standard deviation within and between groups.

2.3. Instruments and measures

2.3.1. Data collected before group formation

The initial survey included questions on personality traits, motivation, prior knowledge, and group orientation. Participants answered all the questions online using a rating scale ranging from 1 ('not true') to 6 ('true').

2.3.1.1. Personality. We used the short version of the BFI-K questionnaire to measure Big Five personality traits (BFI-K; Rammstedt & John, 2005). The questionnaire shows robust reliabilities in this setting (extraversion: eight items, e.g., 'I am talkative like, I like to chat,' $\alpha = 0.88$, conscientiousness: nine items, e.g., 'I work reliably and conscientiously,' $\alpha = 0.85$, openness: five items, e.g., 'I have an active imagination, I am creative,' $\alpha = 0.69$, neuroticism: four items, e.g., 'I worry a lot,' $\alpha = 0.70$, agreeableness: four items, e.g., 'I easily trust others, I believe in the good in people,' $\alpha = 0.66$).

2.3.1.2. Motivation. We used the expectancy-value-cost scale (EVC) developed by Kosovich et al. (2015), to measure motivation. EVC is a self-report survey designed to measure student motivation within four subscales: Expectancy (four items, $\alpha = 0.76$), value (five items, $\alpha = 0.86$), cost (six items, $\alpha = 0.75$), and interest (six items, $\alpha = 0.85$).

2.3.1.3. Self-assessed prior knowledge. We measured prior knowledge as an average subjective rating (self-estimation) per knowledge topic of course content ('How do you judge your knowledge about the course content regarding [specific topic]') ranging from 0 to 100 points.

2.3.1.4. Group orientation. We measured group orientation using three items (e.g., 'If I have a choice, I would rather work in a group than alone') and demonstrated robust reliability ($\alpha = 0.85$).

2.3.2. Outcome variables

Group members completed online questionnaires four times to assess their experience with group work. To this end, we constructed an evaluation questionnaire that included questions about (1) satisfaction and belief that group work was an appropriate work method (Group

Work Satisfaction), (2) time investment, and (3) number of participating members. In addition to (4), group performance was determined based on the four group assignments rated by the course tutors. Consequently, we collected data for multiple dependent variables over time. These outcome variables were divided into three main headings: satisfaction, time investment, and performance-related dependent variables.

2.3.2.1. Group work satisfaction. Collaborative Group Work Satisfaction is a dependent variable in this study and measures participants' satisfaction with their collaborative group work experience, including their perceptions of learning outcomes, skill-building, and social interactions. The construct consists of 5 items, which participants rate on a 6-point Likert scale (ranging from '1 = does not apply' to '6 = applies'). The items include statements such as "I learned more through the group work than I would have learned alone," "I improved my social skills through the group work," and "I improved my project management skills through group work." Participants are also asked to indicate whether group work was better suited than individual work for the specific practice tasks (e.g., 'Did you learn more through group work than you would have learned alone?'). To ensure the internal consistency of the construct it has been evaluated using Cronbach's alpha, indicating high reliability ($\alpha = 0.89$).

2.3.2.2. Time investment. The construct of time investment was assessed as a means of understanding the level of communication between group members. To subjectively evaluate participants' time investment, they were asked about the frequency of communication in their respective groups using a rating scale of '1 = never' to '6 = very often'. While the construct assessed the mean value of subjective time investment, the questions from which this construct was based did not have to be directly related, as this was a collective indication. Nevertheless, we report this construct for the sake of completeness and note that its internal consistency was good ($\alpha = 0.79$).

2.3.2.3. Performance. We measured group performance based on the points on each of the four group assignments rated by tutors based on previously established criteria catalogue (ranging from 0 to 100 points).

2.4. Data exclusion

We scanned the questionnaire for traces of careless responses and eliminated participants when there were obvious fraud cases as well as cases with incomplete or missing data (Meade & Craig, 2012). Overall, we deleted these three cases.

2.5. Data analysis procedure

We conducted data analysis and tested two hypotheses using statistical software, SPSS 23.2, and R version 4.0.0 (R Core Group, 2014). **Hypothesis 1** aimed to determine whether most variances in our dependent variables (satisfaction with group work, time investment, and performance) could be explained at the group or individual level across all four measurement time points. **Hypothesis 2** examined the effect of grouping by extraversion (homogeneous or heterogeneous) on these dependent variables.

To address data dependencies, we utilized multilevel modeling (MLM) with the package lme4 in R (Bates et al., 2019). The random intercept model (Geiser et al., 2010) served as the simplest example to consider possible dependencies. We used maximum likelihood estimation for parameter estimation, incorporating a penalty term to account for excessively large random effects and aimed to identify groups with consistently positive outcomes for almost all members.

Random effects (group effects) were modified by introducing different predictors. In a sequence of interconnected models, the addition of predictors reduced the variance in random effects (Hox et al.,

2017). Predictors at both student and group levels helped explain some differences between groups. We assumed that consideration of predictors influenced group variances. Building on the earlier analysis steps, we tested [Hypothesis 2](#) to examine the estimated abilities of students (individuals) at the group level, focusing on inter-individual differences between groups.

To assess the extent to which group-level factors contributed to explaining differences between groups, we employed the intraclass correlation coefficient (ICC) as a statistical measure ([Bliese, 2000](#)). Additionally, we used model fit indicators AIC and BIC. We isolated the added value of groups from possible influencing factors and calculated MLMs. To understand how much variance could be explained and how the model fit changed, we introduced the study’s experimental variable in each Random Intercept Model and Random Slope Model. The sizes of the coefficients reflected the relative importance of variables in the respective models, as again demonstrated by AIC/BIC.

3. Results

3.1. Baseline descriptive measures and comparison of experimental groups

To provide context for our study, we initially examined baseline descriptive statistics from the first wave of data collection. These statistics allowed us to compare the mean values of various variables in the two experimental groups before our study began. We conducted *t*-tests on variables such as age, gender, personality traits, motivation, and prior knowledge of the course, all of which were grand mean centered prior to analysis. The aim was to identify any significant differences in the distribution of these factors across the two experimental conditions to ensure that any observed differences in outcomes were a result of our experimental manipulation rather than pre-existing group disparities that might impact the internal validity of our study.

The results showed no significant differences between the groups matched by a heterogeneous or homogeneous contribution of extraversion in terms of gender ($t(164) = -0.11, p = .83$), age ($t(164) = -0.07, p = .53$), prior knowledge ($t(164) = -0.41, p = .82$), group orientation ($t(164) = -1.26, p = .31$), or any other personality traits. To provide additional information, we have included the mean level changes in [Table 1](#).

3.1.1. Visualizing key outcomes over time

Our primary research question concerns the influence of individual differences in extraversion on group work dynamics and outcomes. To investigate this, we present visualizations of mean level changes for the three outcome variables - performance, group work satisfaction, and time investment - across four measurement time points, separately for the two experimental conditions based on extraversion distribution. [Fig. 2](#) illustrates the results for these dependent variables in the order of group satisfaction, performance, and participation for both

heterogeneous and homogeneous groups over four time points.

The figure suggests that the level of extraversion within a group may have varying effects on different outcomes. Differences in satisfaction and time investment have implications for group collaboration, while the similarity in performance may indicate that diverse perspectives and skill sets do not necessarily impact this outcome. However, further analysis, including accounting for the multi-level structure of the data, is necessary to fully comprehend these findings.

3.2. Testing hypothesis 1: contribution of variance by individual- and group-level over time

This section presents multilevel models that explain the variance contribution of parameters. To enhance interpretability, we present predictors that have been grand mean-centered. The Intraclass Correlation Coefficient (ICC), also referred to as the Variance Partition Coefficient (VPC), serves as a valuable metric for assessing variation at each level, especially in models featuring random intercepts. For clarity, we have included all nontrivial ICCs, defined as those exceeding 0.05, to evaluate the significance of higher levels as the ICC increases ([Hox et al., 2017](#)). [Table 1](#) displays the ICCs for the dependent variables in the Intercept-Only Model at both individual and group levels. However, the ICC for the dependent variable ‘performance’ was negligible at the individual level (0.001) and substantial at the group level (0.080) and is therefore not included in [Table 2](#).

3.3. Considering outcomes by the distribution of extraversion at the group-level

3.3.1. Group work satisfaction

To investigate the impact of extraversion distribution on group work satisfaction, we utilized the Random Slope Model. Our findings substantiate [Hypothesis 1a](#). Additionally, we incorporated the experimental condition (extraversion distribution) in both the Random Intercept Model and the Random Slope Model to gauge its explanatory power. Extraversion exhibited significant variance in both models, with the Intercept Model offering a slightly better fit. Contrary to [Hypothesis 2a](#), our results indicate that groups homogeneously formed in extraversion were more satisfied with group work than those with heterogeneous distribution. The summarized results are presented in [Table 3](#).

3.3.2. Time investment

For the variable of time investment, the model for intercepts per individual did not yield the best fit. We compared a model for the Random Intercept of groups to the Intercept-Only Model to determine if a group-level model was a better fit. The best-fitting model for time investment was the intercept-per-group model, affirming [Hypothesis 1b](#). Similar to group satisfaction, we evaluated whether the experimental variable of extraversion distribution could explain the variance. Unfortunately, our results did not support [Hypothesis 2b](#), suggesting that

Table 1
Descriptive measures and mean-level changes between groups in first wave data.

Variables	Heterogeneous <i>N</i> = 84		Homogeneous <i>N</i> = 82		<i>t</i>	<i>df</i>	<i>p</i>	CI	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>				Lower	Upper
Gender	1.32	0.47	1.33	0.47	-0.11	164	0.83	-0.15	0.14
Age	22.19	1.82	22.21	1.46	-0.07	164	0.53	-0.52	0.50
Openness	4.35	0.83	4.45	0.89	-0.72	164	0.41	-0.36	0.17
Extraversion	4.21	0.96	4.27	0.87	-0.39	164	0.27	-0.34	0.23
Conscientiousness	4.37	0.84	4.39	0.80	-0.17	164	0.97	-0.27	0.23
Agreeableness	4.15	1.04	4.08	1.00	0.45	164	0.51	-0.24	0.38
Neuroticism	2.96	1.00	3.14	1.00	-1.15	164	0.29	-0.48	0.12
Prior knowledge	37.48	13.72	38.37	14.25	-0.41	164	0.82	-5.18	3.40
Group orientation	3.75	1.23	4.00	1.36	-1.26	164	0.31	-0.65	-0.14

Note. *N* = 166; CI = Confidence interval. 1 = heterogeneous group formation; 2 = homogeneous group formation. *M* and *SD* are represented as the number of observations and standard deviation, respectively.

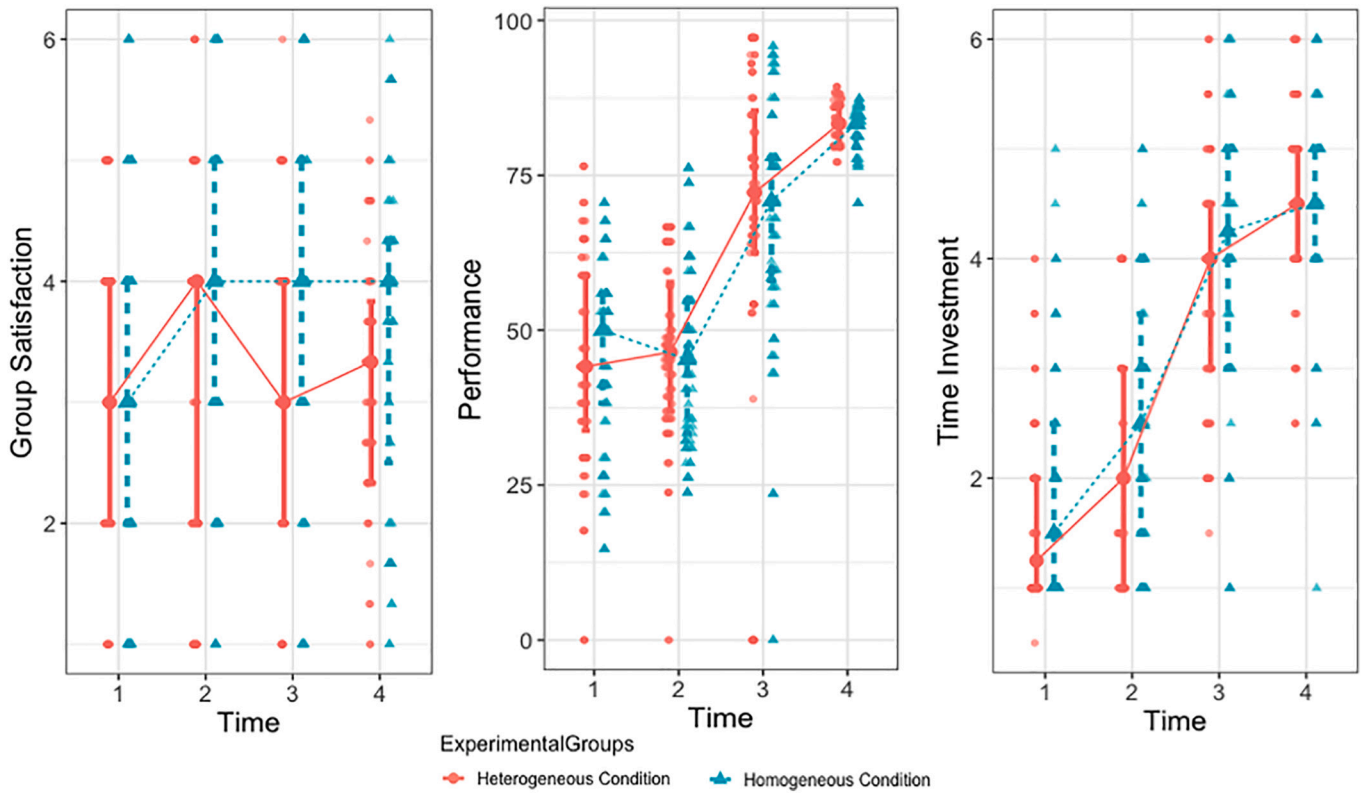


Fig. 2. Group satisfaction, performance and time investment over time.

Note. Fig. 2 presents the outcomes for both groups over the four time points. Results (left to right): First time point heterogeneous groups slightly higher in satisfaction, similarly at the second time point, at the third and fourth time points, homogeneous groups with higher satisfaction, heterogeneous group with lower standard deviation. Performance by heterogeneous groups slightly better. More time investment by homogeneous groups for all measurement time points, with the similar standard deviations.

Table 2 Results of random intercept-only model per individual and group-level.

	Individual-level	Group-level
Satisfaction group work	39 %	44 %
Time investment	33 %	57 %

Note. Indication of percentages, residual variance remains open.

Table 3 Individual-level and group-level predictors of dependent variable group work satisfaction.

	Random Intercept Model	Random Slope Model
Experimental condition	0.31 (0.22)	0.38* (0.19)
Constant	3.21** (0.15)	3.23** (0.13)
Observations	404	404
Log likelihood	-682.24	-682.69
AIC	1376.48	1381.39
BIC	1400.49	1413.40

Note. Experimental Condition: Criterion Extraversion heterogeneous = 0 homogeneous = 1. Unstandardized coefficients were reported. Robust standard errors are reported in parentheses. Missing data handled with case deletion. * $p = .05$; ** $p = .01$.

groups with a heterogeneous distribution of extraversion did not outperform those with a homogeneous distribution. These detailed findings are provided in Table 4.

Table 4 Individual-level and group-level predictors of dependent variable time investment.

	Random Intercept Model	Random Slope Model
Experimental condition	0.13 (0.18)	0.13 (0.18)
Constant	3.00** (0.12)	2.99** (0.12)
Observations	523	523
Log likelihood	-943.94	-943.85
AIC	1899.88	1903.70
BIC	1925.43	1937.78

Note. Experimental Condition: Criterion Extraversion heterogeneous = 0 homogeneous = 1. Unstandardized coefficients were reported. Robust standard errors are reported in parentheses. Missing data handled with case deletion. * $p = .05$; ** $p = .01$.

3.3.3. Performance

Like time investment, we tested performance using the Random Intercept Model and compared it to the Intercept-Only Model to determine the best fit. The best-fit model for performance was the model for the intercept of individuals per group, representing a three-level model structure. As with previous analyses, we introduced the experimental variable of extraversion distribution to both the Random Intercept Model and the Random Slope Model. Our results substantiate Hypothesis 1c, indicating that group-level factors significantly influence performance outcomes. However, Hypothesis 2c, positing that heterogeneously distributed groups would outperform homogeneously distributed groups, was not supported. Detailed results are provided in Table 5.

Table 5
Individual-level and group-level predictors of performance.

	Random Intercept Model	Random Slope Model
Experimental condition	−0.15 (1.61)	−1.16 (1.77)
Constant	26.92** (1.14)	27.12** (1.25)
Observations	619	487
Log Likelihood	−2677.81	−2117.74
AIC	5367.62	4251.47
BIC	5394.18	4284.98

Note. Experimental Condition: Criterion Extraversion heterogeneous = 0; homogeneous = 1. Unstandardized coefficients were reported. Robust standard errors are reported in parentheses. Missing data handled with case deletion. * $p = .05$; ** $p = .01$.

4. Discussion

Based on the research question of the impact of extraversion variance on group formation, this study aimed to investigate the role of group formation (*Hypothesis 1*) by experimentally manipulating the distribution of extraversion in groups and examining its effect on outcomes (*Hypothesis 2*). To achieve this, an experiment was conducted in which participants were randomly assigned to either heterogeneously or homogeneously distributed groups based on their level of extraversion. The outcomes assessed in this study were group work satisfaction (a), time investment (b), and performance (c). In line with *Hypothesis 1*, we provide evidence of the relevance of group formation as a crucial factor in group work, while the rejection of *Hypothesis 2* raises questions about the assumption of the benefits of extraverted individuals as leaders in collaborative learning.

4.1. Interpretation of results based on group roles and hierarchies

The results of the study are aligning with *Hypothesis 1*, which states that group-level variance plays a more important role in explaining outcome variables than individual-level variance. This finding is in line with previous research on the effects of group formation (Horwitz & Horwitz, 2007; Loignon et al., 2018; Mannix & Neale, 2016; Voltmer et al., 2022), highlighting the importance of considering group formation as a relevant factor in group work. However, further analysis of other outcome measures is warranted.

Based on our results, *Hypothesis 2* needed to be rejected. However, the result here was contrary to our initial expectations as it revealed that groups formed homogeneously in extraversion showed significantly higher levels of group work satisfaction. While this finding contradicts some previous studies (French & Kottke, 2013; Humphrey et al., 2007, 2011), it is consistent with Wilson et al.'s (2016) study, which demonstrated that groups composed of members with similar levels of agreeableness and extraversion tend to express more positive emotional displays during negotiation, leading to faster agreements, less relationship conflict, and more positive impressions of their negotiation partners, regardless of whether the groups were similarly high, average, or low in these two traits. Likewise, Jackson et al. (2019) observed a tendency for participants to form groups based on similarity, indicating an unconscious or conscious bias toward homophily over time. Additionally, our results find support in Shemla et al.'s (2016) review, which indicated that perceived group heterogeneity can yield both positive and negative outcomes. This underscores the variability in research on this topic, not only in terms of definitions and concepts but also in methodological approaches to measuring heterogeneity. Furthermore, our study's results challenge the assumption that collaborative learning benefits from the dynamics of an extroverted leader and less extroverted followers. Although a hierarchical group structure has the potential to benefit group effectiveness by increasing coordination and improving communication patterns, it can also create conflicts that harm group

effectiveness, especially when aspects of the group structure and hierarchy itself create conflicts (Greer et al., 2018; Tiedens & Fragale, 2003; Woolley et al., 2022). Rather than relying on a hierarchical structure, our results suggest that group work can be a suitable working method for groups homogeneously formed in extraversion, as such a distribution was experienced as significantly more satisfying by its members.

The finding of significantly higher levels of group work satisfaction based on the homogeneous distribution of extraversion is important because positive experiences with group work can shape students' perceptions and attitudes toward working collaboratively, as an intricate link of group effectiveness to the satisfaction of its members (Harris et al., 2017; Lu & Hu, 2005; Mohrman et al., 1995). Therefore, higher education institutions must prioritize student satisfaction in their group work activities to ensure a more positive and successful long-term experience (Fazal-e-Hasan et al., 2021). Previous research has demonstrated a strong relationship between students' past and present group experiences, highlighting the importance of individual satisfaction as a critical factor for future collaborative work (Peeters et al., 2006). A negative group work experience can lead to negative anticipation of future group work exposure, while a positive experience can lead to more anticipating and socially skilled group work behavior in the long term and reinforce the benefits of learning in small groups (Hillyard et al., 2010).

Research on the different effects of group formation considering the heterogeneous and homogeneous distribution of criteria is limited. A meta-analytic integration of previous research on the effects of homogeneous and heterogeneous groups found relatively small combined effect sizes in favor of heterogeneous groups (Bowers et al., 2000), suggesting that differences may not be substantial. However, researchers may not always be able to establish a convincing causal relationship between the chosen research design for group formation and observed results. Here, not considering criteria related to personality traits before the group formation led to lower results (Revelo-Sánchez et al., 2021). This is particularly true when neither an experimental research design nor theoretically validated group formation criteria are utilized, which leads to the strengths and limitations of the respective study. Overall, in line with previous findings (Blasco-Arcas et al., 2013), our results emphasize the role of active collaborative learning while integrating technologies to improve students' learning performance. In line with others, the relevance of personality traits must be further experimentally investigated (Maqtary et al., 2019; Revelo-Sánchez et al., 2021). Factors such as gender and specialty play a substantial role in shaping group work dynamics (Kucukozer-Cavdar & Taşkaya-Temizel, 2016), challenging conventional beliefs.

4.2. Strengths and limitations of the study

This study contributes to the existing body of research on group formation by using an experimental design to investigate the role of extraversion distribution. The experimental design allowed causal assumptions to be made about the results, adding to the understanding of the relationship between extraversion and group formation. As such, the strength of this study is the use of an experimental design, which ensures that the effect of extraversion on group formation can be isolated and attributed to the independent variable rather than other extraneous factors. Furthermore, the use of a university seminar structure in the research setting provides several benefits for studying group formation and its outcome variables. This setting allows for the examination of group work over a longer period, providing valuable insights into group development and dynamics. The use of longitudinal data and consistency of the groups working on tasks over the course of the study enhanced the generalizability of results. Additionally, the study utilized a robust methodology that minimized the potential for errors and biases in the results. An algorithm that considers individual differences provides a cheap and economical means for group formation in various contexts such as education, business, and the public sector.

Despite these strengths, some limitations of this study should be considered when interpreting its findings. One major limitation is the small sample size, which may have affected the statistical power of the study and its ability to detect significant effects. This was particularly relevant given the high standard deviation of extraversion scores among participants, making it challenging to detect the effect of different grouping extremes due to statistical power. A general limitation concerns the underlying field experimental conditions, in which one cannot control or account for all potentially confounding variables. Another limitation is the potential bias of the self-reported data. Participants were asked to report their thoughts, behaviors, and experiences, which may not always be an accurate representation of their true experiences. In line with this, subjective responses in homogeneous groups might be considered less objective or accurate than responses in heterogeneous groups (Apfelbaum et al., 2014), which provides the potential for misleading interpretations of the effects found. Additionally, as personal information is required to form groups, it is essential to consider the willingness of individuals in a particular setting to take a personality test as part of the group formation process, which may impact the generalizability of these findings to other contexts. Replication issues may arise with the construct used in the study ‘Group work satisfaction scale.’ It is necessary to replicate studies with the construct and adhere to current reporting standards, including measures of internal consistency and evidence of convergent and discriminant validity. However, further research is needed to fully address these concerns.

Additionally, the results of this study are limited in their generalizability to other populations outside higher education. While the sample was representative of the population being studied, it included a pre-selected set of people, such as students majoring in teacher education, in a specific age range in the given set of the course structure. Therefore, these findings may not necessarily be applicable in other populations or settings. This emphasizes the need for further research to better understand the effects of homogeneity on group outcomes.

4.3. Contributions and implications for the research field and educational practice

The present study has made valuable contributions to understanding the relationship between group formation, distribution of extraversion, and several group work outcomes. However, given the strengths and limitations of this study, several key issues must be addressed in future research to deepen the understanding of the underlying mechanisms and implications.

First, the results of this study challenge previous research that supports the superiority of a heterogeneous distribution of extraversion as homogeneously distributed extraversion was found to enhance group work satisfaction. However, such conflicting findings highlight the need for further research into the makeup of groups’ extraversion. When replicating the study, researchers should focus on enhancing the application of experimental research. Here, the methodological difficulties of researching groups can usually be solved only through appropriate research designs, methods, and reviews based on experimental study results to contribute to theory building in such an important area (Shemla et al., 2016).

Therefore, secondly, some methodological implications should be considered. The experimental design for future research must be stressed. Additionally, increasing the sample size enables the examination of context-specific effects and increases the generalizability of the findings. Incorporating control groups, for example, with no group formation, and using other objective outcome measures or group process data, such as video analysis and qualitative data, is recommended to improve the validity of the results and reduce the influence of extraneous factors. An exemplary outcome measure is the observational rubric for assessing collaborative disciplinary engagement in groups (Rogat et al., 2022). This approach takes advantage of observational methods and provides a rubric for quality assessments that enable

efficient qualitative analysis of larger samples.

Third, besides replicating previous findings, research should examine the impact of extraversion under different conditions (e.g., school, workplace, or private study groups), settings (e.g., short-term vs. long-term, voluntary vs. mandatory, and present vs. virtual), and populations (e.g., students from other disciplines, schoolchildren, adults, persons with special needs, and educational requirements). Replicating and extending the findings across different populations, settings, and conditions would allow for greater generalizability and enhance our understanding of the mechanisms underlying group-work hierarchies and enable us to better predict group outcomes.

Future research should consider additional criteria for group formation, such as more indirect components of group work, like the attributes of communication skills, fluency in using computers, and group work attitude (Acharya & Sinha, 2018). As Chen and Kuo (2019) state, that, while it is essential to acknowledge the benefits of systematic group formation, further research is needed to explore the implications of diverse group roles and the potential influence of factors such as gender diversity.

Finally, some practical implications for education can be derived from this research, including a stronger focus on systematic group formation, evaluation of group work satisfaction in addition to performance, and potential for data-driven approaches (e.g., algorithmic group formation) in the educational sector. However, ethical considerations, such as informed consent, proper authorization for psychometric tests, and privacy must be considered when implementing such strategies. In line with others, we recommend the utilization of genetic algorithms for group formation in collaborative learning scenarios (Ani et al., 2010; Revelo-Sánchez et al., 2021) and propose to further explore personality traits as a grouping criterion, in line with recent experimental research employing validated constructs (Revelo-Sánchez et al., 2021). In university settings with small groups within selective work environments, where students are often grouped without the option to decline applications, our methodology presents clear advantages. Dealing with a predetermined population and the need for effective grouping of all students makes an algorithmic approach, accounting for individual differences like extraversion, essential for optimizing group outcomes (Shemla et al., 2016).

While our initial hypotheses on the superiority of heterogeneous extraversion distribution in groups lacked support, noteworthy groups homogeneously distributed in extraversion significantly impacted satisfaction. In our study, the group performance score showed overall little variance, limiting the potential to differ between experimental groups. However, group performance is closely tied to member satisfaction, with dissatisfied members known to hinder overall performance (Mohrman et al., 1995). Moreover, individual satisfaction within group contexts has broader implications for future collaborative work (Peeters et al., 2006). Recognizing and nurturing individual satisfaction within group settings could lead to downstream effects, potentially reducing absenteeism (Makary et al., 2006), considering its significance in university student life. Despite the well-established association between extraversion and positive affect (Wilt et al., 2012), this finding underscores the crucial role of satisfaction in group dynamics.

Given our predominantly female sample, it’s imperative not to overlook gender dynamics, aligning with Woolley et al.’s (2022) findings suggesting that a higher proportion of women in a group can enhance overall group performance. Hence, understanding the influence of gender on group interactions is critical, guiding group formation strategies in university contexts. Additionally, the significance of interaction quality and quantity on collaborative learning outcomes should be considered in group work research, as highlighted by Yücel and Usluel (2016), aiding in better understanding the dynamics of group work settings.

In professional work environments, where there’s typically more control over group member selection, the applicability of our approach may vary. Tailoring the approach according to project goals becomes

essential, particularly in tasks involving diverse responsibilities where factors like extraversion and other traits might significantly shape the hierarchical structure of the group.

Moreover, when dealing with culturally diverse groups, acknowledging the influence of cultural context is imperative. While our study focused on a Western academic population, recognizing that different cultures may have distinct preferences regarding extraversion is crucial. Future research should explore how extraversion impacts group work within diverse cultural contexts, enriching our comprehension of how cultural factors interact with personality traits.

Distinct student populations may exhibit specific differences in group formation outcomes (Acharya & Sinha, 2018). In initial programming courses, considering personality traits notably improved collaborative performance, especially in software development activities (Ani et al., 2010; Revelo-Sánchez et al., 2021). Besides these differences, various factors such as group composition, setting, and the relevance of the group work situation should be carefully considered in each unique case to craft nuanced and tailored group formation solutions.

In the realm of human-AI collaboration and learning in Computer-Supported Collaborative Learning (CSCL) environments, our research implies potential extensions. Our study sheds light on the roles that AI-based systems can undertake within a group. Similar to human group members, AI can assume varied roles such as a tutor, evaluator, peer, or manager (Seeber et al., 2018). The significance lies in carefully considering these roles when forming AI-human groups for specific tasks in learning environments. The findings underscore the importance of distributing tasks meaningfully, leveraging the complementary capabilities of humans and AI, rather than having AI take over every role within a group.

The research on AI-based group roles emphasizes the context-specific nature of choosing the role for an AI system. While AI can enhance human cognition in decision-making tasks (Jarrahi, 2018) or act as an idea evaluator (Maher & Fisher, 2012), this role assignment should be deliberate and aligned with the specific learning objectives and context in CSCL settings. For instance, an AI-based system might serve as an emotional support agent (Hofeditz et al., 2022) or a peer (Elshan & Ebel, 2020), depending on the learning goals. Moreover, our research contributes to the understanding of the role of group formations. Similar to human-only groups, the effectiveness of AI-human groups hinges on contextual factors, the nature of tasks, and specific objectives. It is crucial to assemble groups that harness each other's skills and capabilities, leading to higher performance and superior outcomes.

4.4. Conclusion

In summary, our study highlights the impact of extraversion-based group formation on group work outcomes in a higher education setting. Specifically, groups with a homogeneous extraversion distribution tend to report higher satisfaction in their group work than those with heterogeneous distribution. These findings stress the importance of considering both individual personalities and the collective extraversion traits within groups to enhance overall outcomes. Challenging existing assumptions, these outcomes highlight the intricate nature of group dynamics, urging further research to devise effective strategies adaptable across various contexts. Our study contributes to comprehending the framework for successful group work, particularly in educational and professional domains, laying the groundwork for future research by utilizing algorithmic group formation. However, to fully comprehend broader implications and limitations, additional research remains imperative. We advocate for continued exploration into the makeup of group members' personality traits as pivotal elements in forming highly effective groups.

AI-statement

During the preparation of this work the authors used no AI Tools.

Data statement

Data are not available due to their private character.

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Declaration of competing interest

All the authors declare that they have no established conflicting financial interests or personal relationships that may have influenced the research presented in this paper.

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We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us. We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

Regarding ethical considerations, any aspect of the work covered in this manuscript that has involved human patients has been conducted with the ethical approval of all relevant bodies, and as such are acknowledged within the manuscript.

We understand that the Corresponding Author is the sole contact for the Editorial process, and we have provided a current and correct email address accessible by the Corresponding Author.

Data availability

The data that has been used is confidential.

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