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# Effects of Gender and Group Composition on Higher Education Students' Application of Collaborative Problem-Solving Skills

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**Abstract:** Supporting the development of collaborative problem-solving (CPS) skills without reinforcing existing skill gaps is a crucial task in 21st-century education. Studies showed that female students tend to outperform male students. However, the complex effects of gender group composition remain inconclusive. We investigate the effects of gender and group composition on higher education students' CPS skill application with an experimental mixed-factor design leveraging log data from 200-280 pre-service teachers collaborating in an online learning environment.

## Theoretical background

The development of collaborative problem-solving (CPS) skills constitutes a central task of the 21st-century education system in general and, consequently, of higher education (Fiore et al., 2018; Graesser et al., 2018). According to an established CPS Ontology (Andrews-Todd & Forsyth, 2020), CPS comprises nine measurable high-level skills, such as sharing information, negotiating, and executing. Prior studies demonstrated a gender-skill gap in collaborative learning and CPS, with female students consistently outperforming male students (e.g., Bahtiar et al., 2023; Borgonovi et al., 2023; Lin et al., 2019). To support the training of CPS skills without reinforcing this societal-skill gap, it is crucial to establish conditions under which CPS skills can be applied and thereby practiced regardless of gender.

Gender group composition is a relevant determinant of individuals' collaborative behavior in educational settings (Scoular et al., 2020). Evidence is mixed. Studies suggest that female and male students exhibit more collaborative behavior in groups with more students of their own gender (e.g., Beroíza-Valenzuela et al., 2025; Feng et al., 2023; Kube et al., 2022). At the same time, a higher ratio of female students in small groups is associated with more positive group dynamics and more collaborative behavior in both female and male students (e.g., Curşeu et al., 2018; Dowell et al., 2019; Garcia et al., 2022). Hence, existing findings diverge regarding the effect of gender group composition on collaborative behaviors, especially for male students. Moreover, previous studies focused on different indicators of collaborative processes, whereas findings regarding students' application of CPS skills are limited.

## The present study

With this study, we aim to gain insights into the complex effects of gender and gender group composition on higher education students' application of CPS skills by investigating the following research question:

*How do students identifying with different genders apply CPS skills in small groups?*

To answer this question, we a) investigate how the application of CPS skills differs between female and male students, b) explore how gender group composition is related to students' application of CPS skills, and c) explore how female and male students apply CPS skills across different gender group compositions. In addition, we explore the differentiated application of CPS skills across the nine high-level domains described by Andrews-Todd & Forsyth (2020). Our study is the first step towards educational interventions that enhance the application and, thereby, the practice of CPS skills for all students, regardless of gender. Moreover, our findings will

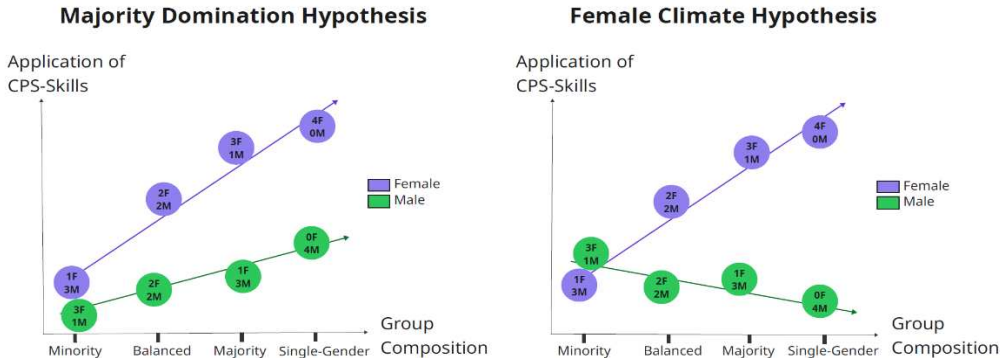
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contribute to the development of inclusive teaching practices, including group formation strategies and instructional designs, that enable equitable CPS skill development across students from diverse genders.

We refer to gender group composition as the number of a student's group members with the student's gender. Based on the literature reviewed, we hypothesize that female students, overall, apply more CPS skills than male students. Furthermore, as prior literature is inconclusive about the effect of gender group composition on collaborative behavior, we explore two contrasting hypotheses (see Figure 1). The *majority-domination hypothesis* posits that both male and female students apply more CPS skills in groups with more members of their own gender, implying a main effect of gender group composition. In contrast, the *female climate hypothesis* posits that groups with more female members foster a more prosocial group environment, with more application of CPS skills in both female and male members. This implies an interaction effect of gender and gender group composition.

**Figure 1**

*Explored Hypotheses About Students' Application of CPS Skills in Small Groups*




Gender group composition describes the number of a student's group members with the same gender in groups of four: minority (the student is the only group member with their gender), balanced (one other group member with the same gender), majority (two other group members with the same gender), and single-gender (the group comprises only group members with the student's gender).

## Method

The study was preregistered and positively reviewed by an ethics committee. The data collection is ongoing. Based on an a priori power analysis, we plan to recruit a sample of $N = 200 - 280$ German-speaking higher education students enrolled in teacher training study programs. The study employs a mixed-factor design with a between-subjects factor, *Gender* (female and male), and an experimental factor, G*roup Composition,* with random assignment to one of four conditions (minority, balanced, majority, or single-gender). Students who do not identify as female or male are assigned to diverse-gender groups and examined exploratively.

The study is completed in an online learning environment developed based on educational research (Beukman et al., 2025) that allows students to chat with each other, write notes, and collaboratively edit a shared document. All students participate in two collaborative professional vision tasks (Seidel & Stürmer, 2014) in randomly assigned groups of four, with a maximum duration of 30 minutes. The tasks involve collaborative analysis and evaluation of a classroom video clip and developing an improvement plan for the teacher. Additionally, we assess sociodemographic, cognitive, and motivational variables, such as socioeconomic background, mental effort during the task, and ability self-concept in CPS, with three online questionnaires.

We collect log data on students' tab switching and video playback, as well as the content of their messages, notes, and edits in the collaborative document. We annotate students' application of CPS skills in the log data with two independent raters, following the qualitative coding strategy of Andrews-Todd & Forsyth (2020). To this end, we adapted the author's behavioral indicators for the high-level CPS domains that are included in their ontology to our CPS task and online learning environment. We test our hypotheses using linear mixed-effect models with the *lmer()* function in *R*.

At this time, $n = 47$ (34 female, 13 male, 0 diverse) students participated in the study, approximately half of them bachelor's students and half of them master's students. Across both tasks, the students collaborated in 21 groups of four: 6 single-gender groups, 6 balanced groups, and 9 majority- and minority groups. On average, 135 relevant log entries per completed task (almost 3000 entries in total) were extracted from the online environment.

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