



Northern Illinois University

RIT

Enhancing Design Teamwork Experiences and Learning in Engineering Education

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Introduction

Forming collaborative teams is a critical first step in team-project-based design courses as team composition directly affects not only teamwork processes and outcomes, but also teamwork skills and experience [Nepal, 2016]. Unfortunately, in one survey across multiple disciplines including engineering, 32% of students experienced poor or very poor group work and 27% of students were unsatisfied with their teams and the division of tasks among the team members [Hall and Buzwell, 2012]. Rather than contributing to team projects, some students resorted to social loafing [Latané, et al., 1979]. Social loafing tends to destroy both teamwork performance and individual learning, especially in solving ill-structured problems, such as design [Webb, 1997]. Furthermore, a bad experience on a past team is a significant concern as it could generate negative feelings toward future team projects [Lewis, et al., 1998; Pfaff and Huddleston, 2003].

Driven by the need to improve students' collaboration, which is expected to enhance team performance and teamwork learning, we aim to answer following research questions in this project: 1) which student characteristics enhance team member collaboration, 2) how can we form collaborative student design teams based on these characteristics, and 3) what team-building design exercises effectively improve team member collaboration.

Research Tasks

Preliminary to answering above research questions, we studied in this presentation if characteristics of senior design students differ between online vs. face-to-face instructions or between institutions. Built on our model of design team effectiveness and a review of instruments for measuring student characteristics [Takai and Esterman, 2019], we collected about forty student characteristics in multidisciplinary capstone senior design courses at Northern Illinois University (NIU) and Rochester Institute of Technology (RIT) that included

1. Background information (major, race/ethnicity, gender, parents' education, and working condition),
2. Work structure preferences (task execution, mode of communication, and team roles),
3. Personality (Big Five personality [Donnellan, et al., 2006] and cognitive modes [Wilde, 2009]),
4. Ability (GPA and decision making [Kahneman and Tversky, 1979; Tversky and Kahneman, 1986]),
5. Motivation (Academic Motivation Scale and its subscales [Vallerand, et al., 1992]), and
6. Attitude (social loafing tendency [Schippers, 2014], sucker effects [Abele and Diehl, 2008], social compensation [Williams and Karau, 1991], tolerance to ambiguity [Budner, 1962], and tolerance to uncertainty [Freeston, et al., 1994]).

We compared individual characteristics 1) within the same institution when the courses were taught online in 2020-2021 (NIU-20 or RIT-20) vs. face-to-face in 2021-2022 (NIU-21 or RIT-21) and 2) between two institutions, NIU vs. RIT, when the courses were taught online or face-to-face.

Methods

We surveyed students in senior design courses at NIU and RIT taught online in 2020-2021 (maximum NIU=35, RIT=107 responses) and face-to-face in 2021-2022 (maximum NIU=136, RIT=219 responses). We performed Chi-square test to compare distributions of categorical variables, i.e., student characteristics in 'Background information' category and GPA in 'Ability' category. We performed analysis of variance test (ANOVA) to compare averages for all other student characteristics. P-value of 0.05 is used for testing statistical significance.

Results

Figure 1 compares student characteristics within each institution (online vs. face-to-face) and between two institutions (NIU vs. RIT). In the figure, red cells highlight p-values less than 0.05 (statistically significant differences). Green cells show p-values between 0.05 and 0.10 (moderate differences). Uncolored cells indicate p-values larger than 0.10 (no statistically significant differences). Hyphens illustrate that Chi-square test could not be performed due to small number of data in some categories.

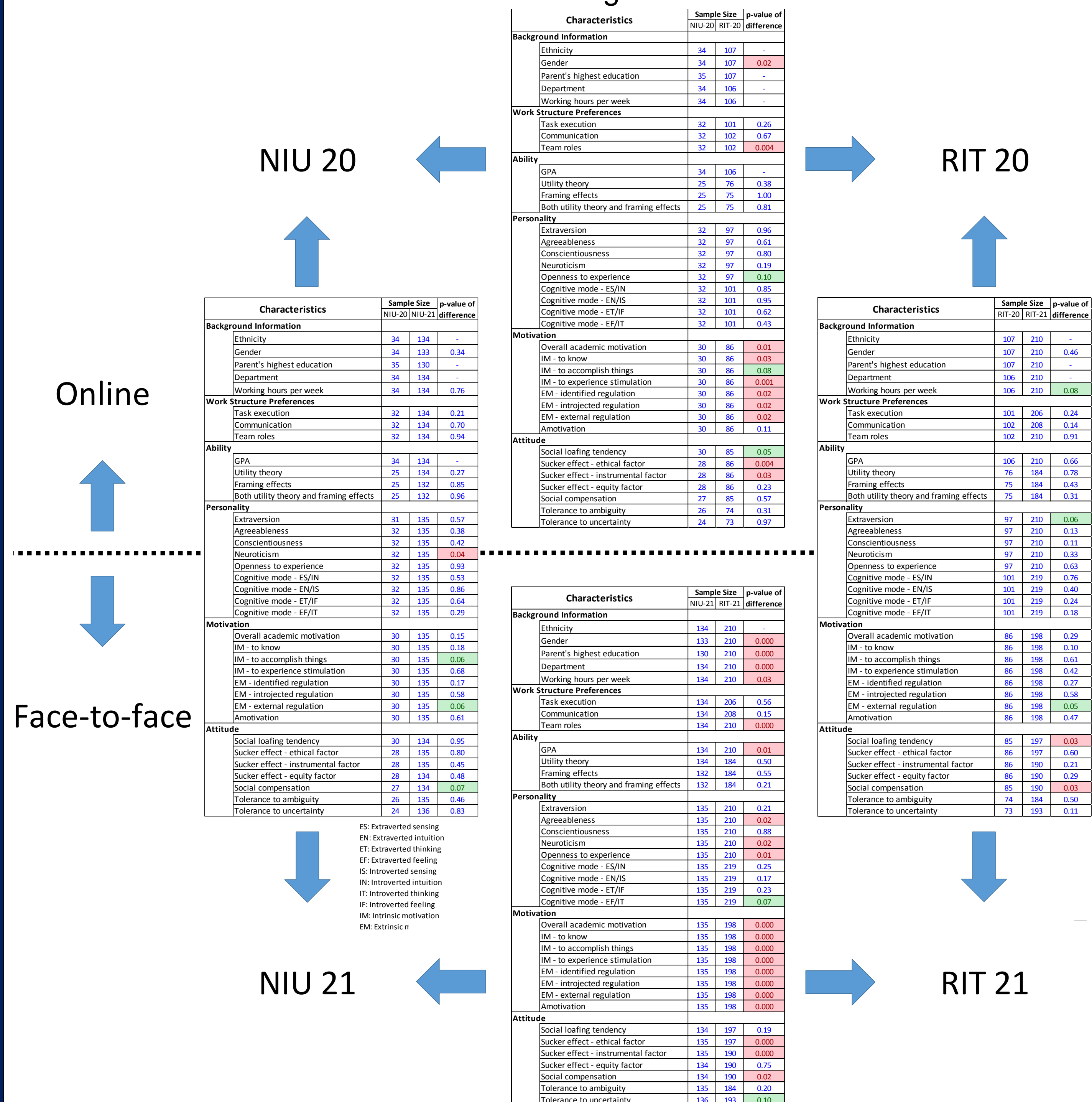


Figure 1: Comparison of student characteristics 1) within the same institution (online vs. face-to-face) and 2) between two institutions (NIU vs. RIT).

When distributions or averages of student characteristics were compared at each institution (senior design courses taught online vs. face-to-face), only one at NIU and two at RIT out of about forty student characteristics were significantly different. Thus, there was no significant evidence that the mode of instruction was relevant to the distributions or averages of student characteristics at each institution.

In contrast, when the distributions or averages of student characteristics were compared between institutions, 10 student characteristics (NIU-20 vs. RIT-20) or 20 students characteristics (NIU-21 vs. RIT-21) were significantly different. For example, in 2021-2022 (NIU-21 vs. RIT-21),

- There were fewer female students and fewer parents with graduate or professional degrees among NIU students.
- There were more RIT students in a higher GPA category.
- RIT students preferred fixed role among team members compared to NIU students.
- NIU students scored lower in Agreeableness and Neuroticism, and higher in Openness of Big Five personality; higher in academic motivation scales and lower in academic amotivation scale; higher in sucker effects (less tolerant to social-loafing); and lower in social compensation (less forgiving to social-loafing).

Thus, student characteristics were significantly more different between institutions compared to within institutions.

Conclusions

Comparison of about forty student characteristics in senior design courses at NIU and RIT taught online in 2020-2021 (NIU-20, RIT20) and face-to-face in 2021-2022 (NIU-21, RIT-21) indicated that student characteristics were similar within each institution regardless of the modes of instruction (online or face-to-face); however, there were significant differences in student characteristics between NIU and RIT. These results implied that same team-formation methodology may be used within the same institution as student characteristics were comparable regardless of whether the senior design courses were taught online or face-to-face. Institution-specific team-formation methodology may be needed as student characteristics differ across institutions. These results indicated that a procedure to create team-formation methodology that caters to each institution's unique student characteristics may be needed in order to disseminate and replicate project outcomes more broadly.

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