A comparison of the university mathematics learning environment with its high school equivalent

Peter Klosterman1 · Stephen Stein1

Received: 26 February 2021 / Accepted: 29 August 2022 / Published online: 12 November 2022
© The Author(s), under exclusive licence to Springer Nature B.V. 2022

Abstract
In light of rising college student debt, many states now offer multiple options for students to earn college credit while still in high school. Concurrent enrollment programs, which allow qualified high school teachers to teach college credit-bearing classes in the high school, are one such option. Because concurrent enrollment classes teach college-level material at college-level rigor, they offer an ideal way to compare the secondary and tertiary learning environments across identical academic expectations. This study sought to compare the university mathematics environment with its concurrent enrollment counterpart. The WIHIC was found to be valid and reliable for the university population. The comparison of 242 students in university classrooms with 260 students in concurrent enrollment classrooms revealed a statistical difference, with the concurrent enrollment setting scoring higher in Involvement, Teacher Support, and Student Cohesion and the university setting scoring higher in Task Orientation. This implies that earning college credit in a secondary setting is a viable, and possibly even preferable, alternative to earning it in a university setting. We examine the discrepancy in scores—particularly the large discrepancy in Task Orientation—and discuss the benefit of the flipped classroom as one path to improving the university learning environment.

Keyword College debt · Concurrent enrollment · Flipped classroom · MANOVA · WIHIC

Introduction

The cost of tertiary education and resulting student debt continue to increase. Indebted U.S. college graduates must repay an average of roughly $30,000 (Institute for College Access & Success, 2020), while their Canadian counterparts must repay $13,000 (Canada Student Loans Program, 2020). Indebted Scottish graduates have incurred $19,000 on average while English graduates face a whopping $55,000 (Student Loans Company, 2020). Financial pressure is one of the biggest factors jeopardizing college completion (Public
Agenda, 2011). Longitudinal data suggest that student debt continues to negatively impact mental health in post-college life (Walsemann et al., 2015).

Dual-credit programs, where a high school student simultaneously earns college credit, are one way to alleviate rising college costs. By reducing the number of classes that must be taken at college, dual-credit programs allow students to graduate sooner, paying less tuition along the way.¹ An earlier graduation also allows students to begin any debt repayment at a younger age. Furthermore, earning college credit in high school also allows students to explore new courses in college or courses that they otherwise would not be able to. Doing so might enable students to discover new interests or topics that genuinely interest them and enrich their lives.

As dual-credit continues to grow in popularity, many secondary students in the U.S. now have the option of multiple dual-credit programs to choose from. Programs can be separated into two broad categories: ones where students remain at their high school and take college-level classes, and ones where students travel to a nearby college and participate in university classes.² Given this choice of dual-credit options, policymakers may wonder which program(s) should be prioritized given limited resources and parents may wonder which program is best for their child. Since more desirable learning environments have been linked to superior academic and affective outcomes (Fraser, 2012), a better understanding of how the secondary and tertiary learning environments compare can help inform these types of questions. However, the tertiary setting has received little attention from classroom environment researchers. While studies of the secondary learning environment have proliferated over the years (Alansari & Rubie-Davis 2019; Skordi & Fraser, 2018), only recently have researchers begun validating survey instruments in a tertiary setting (e.g. Skordi & Fraser, 2018; Khine, et al. 2018).

This study compares the secondary and tertiary learning environments across equivalent classes in each setting. Specifically, the study addresses the following two research questions:

1. First, is there an overall difference (as measured by the MANOVA) between the learning environments of university mathematics classrooms and equivalent college-level classes taught in a secondary setting?
2. If so, how do the specific components of the learning environments (as measured by the individual scales of the What is Happening in this Classroom questionnaire) differ between the two settings?

¹ There are, of course, fees associated with many dual-credit programs. However, these fees are far less than the tuition students would otherwise pay if taking the equivalent class at a university.
² Advanced Placement (AP), International Baccalaureate (IB), and Concurrent Enrollment are all examples of dual-credit where the student remains at the high school. However, students in AP and IB programs must pass a high-stakes, end-of-course exam in order to earn college credit. In Concurrent Enrollment, students earn a grade like normal through assignments, quizzes, and exams.
Literature review

Learning environment research

Generally speaking, a learning environment is the “intellectual, social, emotional, and physical environments in which students learn” (Ambrose et al., 2010, p. 170). The roots of learning environment research stretch back nearly a century to the work of early social psychologists. However, the work of Moos (1974) was particularly influential in conceptualizing human environments into three broad categories: relationships, personal development, and systems maintenance and change. In subsequent decades, numerous survey instruments were developed to probe students’ perception of their learning environment via these categories. Currently, one popular survey instrument is the What Is Happening In this Class (WIHIC) instrument developed by Fraser, Fisher, and McRobbie (1996). The WIHIC is an update of a previous survey instrument developed by Moos and Trickett (1974) and uses seven scales to measure the learning environment. We chose to utilize the WIHIC for our study because of its widespread acceptance in the research field today (Dorman, 2008).

Meta-analysis by Fraser (2012) shows clear evidence that desirable learning environments correlate with better academic outcomes and more favorable student attitudes towards the academic subject. A large-scale study by Bonem et al. (2020) involving over 14,000 students found that students’ perception of their learning environment was a better predictor of motivation and academic performance than number of classroom contact hours or use of active learning strategies. As Bonem et al. (2020) state, “what is most important is not necessarily what techniques or strategies the instructor chooses but the way in which those techniques or strategies are implemented and the resulting type of learning environment that the instructor creates” (p. 29).

Bonem et al.’s (2020) conclusion illustrates the difference between low inference and high inference measures of a classroom. Low inference measures are objective measures that can be made by a detached observer (e.g. number of contact hours, type of pedagogy employed, number of times an individual speaks). By contrast, high inference measures subjectively measure the environment as perceived and experienced by members of that environment (e.g. how well the teacher support the students, how well the students get along). High inference measures are considered to exert more influence on student outcomes since they measure what students are feeling, interpreting, and responding to (Dorman, 2002). A low inference measure may detect changes in teacher behavior, but not necessarily whether these changes are affecting the classroom environment. In other words, a teacher’s behavioral change may or may not be perceived by the students. Bonem et al.’s (2020) conclusion provides a clear, empirically-supported example of the greater influence of high inference measures over low inference ones. Thus, comparing the learning environments of university and concurrent enrollment classrooms using a high inference measure allows our study to compare the relative likelihood of academic success in each of these settings.

Use of classroom environment research

Survey instruments have long been used to compare learning environments across school location (e.g. Trickett, 1978), school type (e.g. Skowronek-Ingraffia, 1986), academic subject (e.g. Trickett & Moos, 1995), as well as many other variables (Fraser, 2012). Such
studies have generally found differences of varying degrees, thus supporting the case for further nuanced study of learning environments across different settings, even settings that might initially appear similar.

The vast majority of learning environment research has taken place at the secondary level. Comparatively few studies have probed the tertiary environment (Alansari & Rubie-Davis 2019; Skordi & Fraser, 2018). Using the College and University Classroom Environment Inventory, Nair and Fisher (2000) surveyed 130 students in science classes during their final year of high school and then again the subsequent year in their community college science classes. They found that students tended to view their tertiary environment less favorably, scoring it lower in personalization, student cohesiveness, cooperation, and individualization. However, they did rate the tertiary environment slightly higher in task orientation and innovative teaching strategies. Nair and Fisher (2000) also noted that students found the college transition difficult due to increased workload, faster class pace, and lower concern for students shown by university lecturers.

Skordi and Fraser (2018) validated the WIHIC among tertiary statistics students at two southern California universities, thus furthering the WIHIC’s credibility for tertiary use. Khine, et al. (2018) validated a translation of the WIHIC into the Myanmar language within a tertiary science setting in Myanmar. Cuarto and Arenillo (2015) used the WIHIC to explore the classroom environment of prospective mathematics teachers in a Philippine college. As mentioned earlier, Bonem et al. (2020) used the Learning Climate Questionnaire to survey over 14,000 students at a large U.S. university. They found that a student’s perception of the classroom environment was a better predictor of motivation and academic performance than use of active learning or number of contact hours, thus underscoring the importance of a positive classroom environment in student success. In a study of pre-service teachers in the United Arab Emirates, McMinn and Aldridge (2020) found that higher scores on the WIHIC correlated with lower self-reported levels of mathematics anxiety.

Using the WIHIC, Stein and Klosterman (2020) investigated the learning environment of college-level mathematics classrooms taught in a high school setting. They identified three distinct types of learning environments within this setting based on higher, medium, and lower overall scores on the WIHIC. Furthermore, they found that the three WIHIC scales of Teacher Support, Involvement, and Student Cohesiveness exerted the greatest influence in determining whether the overall score of a classroom was high, medium, or low.

Wilkie (2000) used the Preferred College Classroom Environment Scale to probe college students’ preferred learning environments. She found that college students had a strong preference for high teacher support and high intellectual stimulation, and a slight preference for interaction with other students (e.g. group work).

**Methods**

**Instruments**

This study opted to use the WIHIC because of its widely accepted status and because of its cross-validation in many subject areas and countries (Aldridge et al., 1999; Dorman, 2003; Khoo & Fraser, 2008). Additionally, several studies have already used the WIHIC at the college level (e.g. Cuarto & Arenillo, 2015; Khine et al. 2018). Aldridge et al. (2012) grouped the WIHIC into two categories: Relationship (Student Cohesion, Teacher Support, and Equity) and Delivery (Task Orientation, Involvement, Investigation, and Cooperation.)
See Table 1 for a description of the seven scales of the WIHIC. The eight questions within each scale were answered via a five-point Likert scale with higher scores indicating a more favorable environment (1 = Almost Never, 2 = Seldom, 3 = Sometimes, 4 = Often, 5 = Almost Always).

Each WIHIC scale contains eight items (questions). The Investigation scale was dropped from this study due to errors in administering the WIHIC (see “Statistical analyses” below).

Participants and population

The university population consisted of nine university mathematics faculty and their 247 students at a medium-sized public university in rural Washington State. The classes were surveyed over halfway through the academic term and were all either calculus, pre-calculus, or a lower-level mathematics class. All faculty members held either a masters or PhD and had between one and 45 years of teaching experience with a mean of 16 years.

The second population for the study consisted of mathematics teachers in the same university’s concurrent enrollment program. The concurrent enrollment program allows high school students to take college-level classes taught in the high school by qualified high school teachers. There were 180 mathematics teachers in the program, distributed across 90 different high schools. Schools were located across the state of Washington and included public and private schools, schools of various sizes, and urban, suburban, and rural schools. Calculus, pre-calculus, and finite mathematics courses were surveyed. These were the same courses surveyed in the university sample and were taught to the same standard as the university classes. Thus, the academic content and level of rigor between the two samples was the same; the crucial difference was the secondary or tertiary setting.

All 180 mathematics teachers in the university’s concurrent enrollment program were asked to participate in the study. Of this group, 70 accepted, 10 declined, and 100 did not respond. The 70 teachers who accepted administered the WIHIC to their students after at least three months of the school year had elapsed and also completed a short demographic survey. School principals and students’ parents were notified of the study. Both parents and students were given the opportunity to decline participation if they desired. Two teachers were dropped because of incomplete data. The 68 remaining classrooms represented 1062 students. Teachers’ years of experience ranged from three years to over 20 years, with the vast majority of teachers having over ten years of experience. For additional details on the concurrent enrollment sample, refer to Stein and Klosterman (2020). Table 2 details participating teachers’ years of experience. In order to facilitate statistical comparisons with the university sample, 10 concurrent enrollment classes were randomly selected. Thus, the university sample used for this study consisted of 242 students while the concurrent enrollment sample consisted of 260 students.

Statistical analyses

Since the WIHIC’s validity and reliability was already established for the concurrent enrollment population (see Stein & Klosterman, 2020), it was only necessary to establish validity and reliability for the university population. To validate the WIHIC’s factor structure, we conducted principal component analysis with oblimin rotation and Kaiser
Table 1  The seven scales of the WIHIC

| Scale                  | Description—the extent to which...                                                                 | Sample item                                                                 |
|-----------------------|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Student cohesiveness  | students know, help and are supportive of one another                                           | Students like me in this class                                             |
| Teacher support       | the teacher helps, befriends, trusts, and is interested in students                              | The teacher takes interest in me in this class                             |
| Involvement           | students have attentive interest, participate in discussions, ask questions and share ideas    | I give my opinions during discussion in this class                         |
| Investigation         | there is emphasis on inquiry, problem-solving, and investigation                               | I solve problems by doing my own projects                                  |
| Task orientation      | it is important to complete activities planned and to stay on the subject matter                | I know what I am supposed to learn in this class                           |
| Cooperation           | students cooperate with one another on learning tasks                                            | Students work with me to achieve our class goals                           |
| Equity                | students are treated equally by the teacher                                                      | I can talk the same amount as other students in this class                  |
normalization with seven fixed factors for the 56 items of the WIHIC. The two criteria used for the retention of any item were that it must have a factor loading of at least 0.35 with its own scale and less than 0.35 with each of the other WIHIC scales. Skordi and Fraser (2018) used a factor loading of 0.35 as a criterion for item retention, noting it was consistent with guidelines provided by Hair et al. (1998). Internal consistency was measured using Cronbach’s alpha coefficient.

A one-way multivariate analysis of variance (MANOVA) was conducted to compare the learning environments of the university sample with the concurrent enrollment sample. The MANOVA allowed us to investigate the differences between the two settings with respect to the WIHIC scales. Since the comparison was between only two groups, no post-hoc tests were necessary as means differences were provided by SPSS. Following current practices (e.g. Hatcher, 2013), effect sizes and confidence intervals were also computed. For the comparison, six of the seven WIHIC scales were used. The Investigation scale was removed since many of our concurrent enrollment teachers had instructed their students to disregard it because its questions contained the term ‘laboratory.’

Results

Validity of WIHIC

The university data set was examined for missing scores, outliers, linearity, as well as skew and kurtosis. Skewness and Kurtosis were within acceptable ranges for all scales except Equity. The Equity scale’s skew value of -1.02 indicated a very slight skew. However, since skew values between −1 and 1 are considered acceptable, this value was not viewed as a cause for concern. Mahalonobis distances were used to remove multivariate outliers. Descriptive statistics for the university WIHIC subscales are shown in Table 3. For equivalent descriptive statistics of the concurrent enrollment sample, see Stein and Klosterman (2020).

The factor analysis of the 56-item WIHIC replicated the factor structures found in previous studies (Skordi & Fraser, 2018; Stein & Klosterman, 2020). Fifty-four of the 56 items were retained, having met the criteria of a factor loading of at least 0.35 with its own scale and less than 0.35 with each of the other scales. Two items from the Involvement scale that did not meet these criteria were removed to improve the factorial validity and internal consistency reliability. Table 7 in the appendix section provides more detailed factor analysis results including the percentage of variance accounted for and each factor’s eigenvalue. The proportion of variance ranged from 2.81% to 30.32% for the WIHIC scales. Together,
the seven scales accounted for a total of 64.0% of the variation for the instrument. Scale eigenvalues were all above one—the minimum value for a factor to be meaningful (Kaiser, 1960)—ranging from 1.61 to 16.98.

When Cronbach’s alpha coefficient was used as a measure of the internal consistency (n = 242 students), the coefficients for the various WIHIC scales ranged from 0.791 to 0.833. Overall, the alpha reliability values, shown in Table 3, support the strong internal consistency of all WIHIC scales for our university sample, with all coefficients well above the minimum satisfactory value of 0.70 advocated by various authors (e.g. Nunnally, 1978). Cronbach’s alpha for the entire data set was 0.824.

### Comparison with concurrent enrollment classrooms

The MANOVA investigated possible differences in mean scores on six scales of the WIHIC between the university and concurrent enrollment settings. Additionally, effect sizes using $\eta^2$ (Eta-squared) and confidence interval scores were examined.

Prior to conducting the MANOVA, a series of Pearson correlations were performed between each of the dependent variables (WIHIC scales) in order to test the MANOVA assumption that the dependent variables would be correlated with each other in the moderate range. Meyers et al. (2006) define this range as correlation coefficients between 0.2 and 0.8. As Table 4 shows, a meaningful pattern of correlations emerged among most of the dependent variables. Additionally, Box’s M test provided a value of 176.880, which was
associated with a p value of < 0.001. This indicates a significant difference and potential violation of one of the MANOVA assumptions (Box’s M should have a p value greater than 0.001 in order to meet the assumptions). However according to Hatcher (2013), significant results for Box’s M are not necessarily a cause for alarm since the test is very sensitive. Sample size can overcome violations of this assumption as the MANOVA is robust against modest violations.

Lavene’s F tests were conducted in order to examine the homogeneity of variance assumption. As Table 5 shows, three of the six Levene’s F tests were not statistically significant (p > 0.05), implying the possibility that the homogeneity of variance assumption was not met. However, Howell (2009) notes that if the largest standard deviation is less than four times the size of the corresponding smallest, the MANOVA is still robust. Since the standard deviations for all the scales satisfied this criteria (see Table 3), the homogeneity of variance assumption was considered satisfied.

The MANOVA resulted in a statistically significant effect, Wilk’s Lambda Λ = 0.493, F (5, 502) = 84.681, p < 0.001. The multivariate effect size (η², Eta-squared) was estimated at 0.507, which implies that 50.7% of the variance was accounted for by the class setting (university or concurrent enrollment). Since post hoc tests were unnecessary, means comparisons were made with the MANOVA output. Table 6 presents means, means differences, significance values, F scores, and η² values for of the six WIHIC scales. Mean scores for the concurrent enrollment classrooms were higher for Student Cohesiveness, Teacher Support, Involvement, and Cooperation. The university classroom had higher means for Task Orientation and Equity. Figure 1 provides a visual representation for the mean scores for each WIHIC scale. The error bars represent the 95% confidence intervals for each mean.

Discussion

Research questions

The WIHIC was determined to be a valid and reliable instrument when used in a university environment, thus permitting the comparison with the concurrent enrollment setting to be made. Utilizing the data drawn from 242 students from nine instructors in a medium-sized public university setting, our analysis supported the WIHIC’s validity. Factor analysis of the 56-item WIHIC replicated the factor structure found in previous studies (Skordi & Fraser, 2018), with 64% of the variance accounted for by the seven scales. The WIHIC also
Table 6  Comparisons between classroom types

| WIHIC scale           | Means (SD)                      | 95% CI for means             |
|-----------------------|---------------------------------|------------------------------|
|                       | Concurrent Enrollment | University | F Score | P Value | $\eta^2$ | $\eta^2$ Effect | Concurrent enrollment | University |
| Student cohesiveness  | 3.90 (.61)                   | 3.43 (.78)     | 57.89   | .000    | .104     | medium              | (3.82, 3.99)      | (3.34, 3.52) |
| Teacher support       | 3.75 (.83)                   | 3.56 (.83)     | 6.68    | .010    | .013     | small                | (3.65, 3.86)      | (3.46, 3.67) |
| Involvement           | 3.24 (.74)                   | 3.06 (1.0)     | 5.08    | .025    | .010     | small                | (3.13, 3.34)      | (2.95, 3.17) |
| Task orientation      | 3.06 (.99)                   | 4.29 (.59)     | 282.39  | .000    | .361     | large                | (2.96, 3.16)      | (4.19, 4.40) |
| Cooperation           | 4.22 (.67)                   | 3.45 (1.0)     | 102.41  | .000    | .170     | large                | (4.12, 4.33)      | (3.35, 3.56) |
| Equity                | 3.88 (.71)                   | 4.32 (.72)     | 47.17   | .000    | .086     | medium               | (3.79, 3.96)      | (4.23, 4.41) |

For Concurrent Enrollment, n = 260. For University, n = 242. WIHIC responses: (1 = almost never, 5 = almost always)
demonstrated strong reliability with alpha coefficients ranging from 0.79 to 0.83 for the seven scales. These results lend credibility for the WIHIC’s use in the university classroom.

The MANOVA results (Wilk’s Lambda $\Lambda = 0.493$, $p < 0.001$) indicate that the tertiary and secondary learning environments significantly differ overall. However, since the MANOVA assumptions may have been violated, this particular conclusion should be viewed with caution. In terms of specific components of the learning environment, the secondary setting scored higher in four of the six compared WIHIC scales (Student Cohesiveness, Teacher Support, Involvement, Cooperation). In a previous study (Stein & Klosterman, 2020), we identified three distinct types of learning environments within the concurrent enrollment setting based on high, medium, or low overall scores on the WIHIC. Further analysis revealed that the scales of Teacher Support, Involvement, and Student Cohesion exerted the greatest influence in determining a classroom’s overall score. The current study revealed that all three of these influential scales were higher for the concurrent enrollment setting. Thus, it appears that the concurrent enrollment learning environment is generally viewed more favorably by students.

Our results aligned with Nair and Fischer’s (2000) examination of secondary and tertiary classrooms. They found the secondary learning environment more favorable in personalization (i.e., Teacher Support), Student Cohesiveness, Cooperation, and individualization (i.e., Involvement), but not necessarily in Equity. Nair and Fisher (2000) noted that students’ struggle with the tertiary classroom might be due in part to the heavier workload and faster pace. Concurrent enrollment classrooms have comparable rigor to a university classroom. They must adopt the academic standards of the university course and use the university-provided final examination which must account for 25% of the overall course grade. This suggests that the rigor of college-level work is not the reason for the university classroom’s lower scores. The pace of university classes, however, might contribute to the lower scores. Our concurrent enrollment classes had 90 allotted class days while the university classes had roughly half this number of class days.
days to cover the same amount of material, necessitating an increased pace. This rapid pace may compel university instructors to adopt a more economical, teacher-centered pedagogy, resulting in lower WIHIC scores in Student Cohesiveness, Involvement, and Cooperation, and higher scores in Task Orientation.

Another reason for the higher concurrent enrollment scores, particularly in Student Cohesiveness, might be the cohort-based nature of high school. It is likely that many students in a given concurrent enrollment class already possess a certain level of camaraderie from prior classes or involvement in school activities. Since the WIHIC Student Cohesiveness scale contains questions such as “Other students are my friends in this class,” a concurrent enrollment class enjoys a significant advantage over a university class on this scale regardless of the instructor’s methods. Many university classes—particularly lower-level ones like the mathematics classes we surveyed—contain a broad mix of majors and first-year students and therefore likely lack the initial camaraderie of a concurrent enrollment class.

Implications

The results of this study contain significant implications for university instruction. The largest discrepancy in the comparison occurred in the Task Orientation scale with the university scoring significantly higher than the concurrent enrollment environment. Previous research suggests that high Task Orientation scores may indicate a more traditional classroom with frequent use of direct instruction (Strayer, 2012). This would also explain the university’s lower scores in Student Cohesiveness, Cooperation, and Involvement. Research indicates that most students perform better academically in environments where these three scales are higher (Fraser, 2012; Freeman, et al., 2014; Valtonen, et al., 2020). For instance, Freeman, et al. (2014) found that active learning (i.e. higher Involvement scores) might decrease the failure rate in STEM courses by up to 33%. This suggests that university instruction might benefit from adopting some of the more student-centered, interactive pedagogy used in concurrent enrollment classrooms.

As noted earlier, however, university instructors face significant time constraints compared to their secondary counterparts. Instructors have roughly half the amount of class time to cover the same material while also lacking the initial camaraderie of concurrent enrollment classrooms. Hence, improving the university learning environment will require a concerted effort from instructors to maximize limited class time. One such strategy is a flipped classroom where online resources (e.g. readings, pre-recorded lectures) are provided prior to meeting, effectively moving direct instruction outside the classroom. This frees up additional class time for more interactive work which may increase environment scores in Involvement, Student Cohesion, and Teacher Support. It must be emphasized, however, that the flipped approach merely provides the opportunity for more interaction, not a guarantee of it. To successfully improve environment scores, instructors will need to design class activities that require meaningful interaction while building upon the out-of-class material. This is a non-trivial task that entails numerous challenges

---

4 Some of the challenges identified include: lack of student engagement with out-of-class material, lack of student perseverance with in-class problem-solving, student expectations for a more traditional classroom, and connecting the out-of-class material with the in-class work.
Further complicated by the limited pedagogical training most instructors have received from their graduate programs.

Therefore, broader department and university support will be necessary to successfully implement more interactive pedagogy. Departments should offer professional development and resources, such as Lo et al.'s (2017) helpful list of research-based design principles for a flipped mathematics classroom. Graduate programs should also incorporate this kind of pedagogical training for future instructors. Large university lecture halls with fixed seating hinder many interactive pedagogies. Groups of two to four students, flexible seating arrangements, and numerous vertically hung whiteboards for student use can help encourage interactive work (Liljedahl, 2016). Finally, many universities—particularly larger, doctorate-granting ones—offer little incentive for exemplary or innovative teaching, instead rewarding research publication output and externally funded grants. In the absence of instructor incentives, it is unrealistic to expect widespread change in university pedagogy.

Although implementing interactive university pedagogy faces numerous challenges, there are significant potential benefits for students’ academic outcomes (Freeman et al., 2014). Furthermore, the present time offers a unique opportunity for implementing pedagogical change. The recent Covid-19 pandemic forced most university instructors to try online or hybrid teaching for the first time. Consequently, instructors and students are now familiar with recorded lectures, more extensive use of learning management systems, and various other online resources. This familiarity could ease the transition to the flipped approach mentioned earlier, especially since student unfamiliarity and instructor start-up efforts have historically been the two greatest challenges for the flipped classroom (Lo et al., 2017). Thus, administrative initiatives for flipped classrooms might be especially fruitful during this time.

This study also contains implications for superintendents and legislators. Since high school students now have multiple paths for earning college credit, policymakers must decide which programs should be prioritized given limited time and funding. In Washington State, for instance, students can travel to a local college or university and take classes through the Running Start program, or remain in the high school and earn college credit through concurrent enrollment, AP, or IB programs. Since more desirable learning environments correlate with better academic outcomes (Fraser, 2012), our study implies that remaining in a secondary environment would be the preferred choice for many students. While AP and IB take place in the secondary environment, students must pass a single, high-stakes exam in order to earn college credit. By contrast, concurrent enrollment avoids high-stakes exams while still offering the secondary environment. Therefore, concurrent enrollment may be the better option for students who struggle with testing issues and policymakers should consider fully funding it.

It is worth noting, however, that some students prefer direct instruction over more interactive pedagogies (Valtonen et al., 2020), meaning that their desired learning environment may be one with lower Student Cohesiveness, Cooperation, and Involvement scores. Such students might prefer the university environment to the secondary one and should consider pursuing it if an option.

Limitations and future research

It is important to reiterate that this study was a preliminary investigation designed to address the dearth of research directly comparing the secondary and tertiary learning environments. Accordingly, we took a somewhat liberal approach regarding the MANOVA
assumptions. Additionally, we did not use a Bonferroni adjustment to limit the potential familywise error rate. There is discussion in the literature that the Bonferroni adjustment may reduce the power of the analysis (Nakagawa, 2004). Furthermore, the intent of this preliminary study was to encourage further investigation in a little-researched area. All of the instructors in our university sample were drawn from a single institution, and all concurrent enrollment instructors were likewise drawn from a single program in a single subject (mathematics). Past research indicates that learning environments tend to vary across academic subjects (Trickett & Moos, 1995). Also, one WIHIC scale (Investigation) was not used for comparative purposes.

Due to these limitations, our results must be viewed with caution. In order to make stronger, generalizable comparisons of the secondary and tertiary settings, a more diverse sample is necessary, preferably one spanning multiple institutions and subject matters. Such a sample would permit researchers to investigate trends across university settings (e.g. institution size, class size, public/private).

Given the rising costs of college and proliferation of dual-credit options, it is surprising how little research has directly compared the secondary and university learning environments. Comparisons in other areas besides mathematics are necessary to see if similar differences persist across subjects. Doing so would assist policymakers and educational leaders in directing students to the most effective avenues for earning dual-credit. Future research in this area would also address the National Alliance for Concurrent Enrollment Partnerships’ (NACEP) call for research to provide a more complete picture of how concurrent enrollment contributes to a seamless K-16 education system (NACEP 2016).

Conclusion

This study compared the concurrent enrollment (secondary) and university learning environments since they covered equivalent content at the same level of rigor. We found a significant difference overall between the learning environments with the secondary environment scoring higher on most of the WIHIC scales, thus suggesting this setting might be the better option for most students. Our results imply that universities may benefit from examining the pedagogy of concurrent enrollment instructors. However, broader university support will be necessary to enable instructors to implement new pedagogy successfully. A larger and more diverse sample is necessary to determine if similar classroom environment trends hold across other subjects beyond mathematics.

Appendix

See Table 7.
| Item no | Factor Loadings |
|---------|------------------|
|         | Student cohesive-ness | Teacher support | Involvement | Investigation | Task orientation | Cooperation | Equity |
| Stu Coh 1 | .471 |  |  |  |  |  |  |
| Stu Coh 2 | .554 |  |  |  |  |  |  |
| Stu Coh 3 | .583 |  |  |  |  |  |  |
| Stu Coh 4 | .583 |  |  |  |  |  |  |
| Stu Coh 5 | .649 |  |  |  |  |  |  |
| Stu Coh 6 | .602 |  |  |  |  |  |  |
| Stu Coh 7 | .744 |  |  |  |  |  |  |
| Stu Coh 8 | .614 |  |  |  |  |  |  |
| Tea Sup 1 | −.716 |  |  |  |  |  |  |
| Tea Sup 2 | −.765 |  |  |  |  |  |  |
| Tea Sup 3 | −.795 |  |  |  |  |  |  |
| Tea Sup 4 | −.658 |  |  |  |  |  |  |
| Tea Sup 5 | −.742 |  |  |  |  |  |  |
| Tea Sup 6 | −.700 |  |  |  |  |  |  |
| Tea Sup 7 | −.671 |  |  |  |  |  |  |
| Tea Sup 8 | −.639 |  |  |  |  |  |  |
| Invol 1 | −.206* |  |  |  |  |  |  |
| Invol 2 | −.654 |  |  |  |  |  |  |
| Invol 3 | −.778 |  |  |  |  |  |  |
| Invol 4 | −.703 |  |  |  |  |  |  |
| Invol 5 | −.768 |  |  |  |  |  |  |
| Invol 6 | −.454 |  |  |  |  |  |  |
| Invol 7 | −.440 |  |  |  |  |  |  |
| Invol 8 | −.341* |  |  |  |  |  |  |
| Invest 1 | −.804 |  |  |  |  |  |  |
| Invest 2 | −.601 |  |  |  |  |  |  |
| Invest 3 | −.772 |  |  |  |  |  |  |
| Invest 4 | −.561 |  |  |  |  |  |  |
| Invest 5 | −.822 |  |  |  |  |  |  |
| Invest 6 | −.874 |  |  |  |  |  |  |
| Invest 7 | −.862 |  |  |  |  |  |  |
| Invest 8 | −.713 |  |  |  |  |  |  |
| Task Orn 1 |  |  |  |  |  |  | .658 |
| Task Orn 2 |  |  |  |  |  |  | .693 |
| Task Orn 3 |  |  |  |  |  |  | .718 |
| Task Orn 4 |  |  |  |  |  |  | .532 |
| Task Orn 5 |  |  |  |  |  |  | .738 |
| Task Orn 6 |  |  |  |  |  |  | .639 |
| Task Orn 7 |  |  |  |  |  |  | .746 |
| Task Orn 8 |  |  |  |  |  |  | .739 |
| Coop 1 |  |  |  |  |  |  | .582 |
| Coop 2 |  |  |  |  |  |  | .558 |
### Table 7 (continued)

| Item no | Factor Loadings |
|---------|-----------------|
|         | Student cohesive-ness | Teacher support | Involvement | Investigation | Task orientation | Cooperation | Equity |
| Coop 3  | .710             |                |             |              |                 |             |        |
| Coop 4  | .831             |                |             |              |                 |             |        |
| Coop 5  | .775             |                |             |              |                 |             |        |
| Coop 6  | .782             |                |             |              |                 |             |        |
| Coop 7  | .747             |                |             |              |                 |             |        |
| Coop 8  | .832             |                |             |              |                 |             |        |
| Equity 1| .666             |                |             |              |                 |             |        |
| Equity 2| .808             |                |             |              |                 |             |        |
| Equity 3| .767             |                |             |              |                 |             |        |
| Equity 4| .774             |                |             |              |                 |             |        |
| Equity 5| .804             |                |             |              |                 |             |        |
| Equity 6| .830             |                |             |              |                 |             |        |
| Equity 7| .774             |                |             |              |                 |             |        |
| Equity 8| .717             |                |             |              |                 |             |        |

% Variance: 3.024 4.256 6.641 2.881 5.116 30.317 11.710 1.693 2.383 3.719 1.613 2.865 16.978 6.558

Eigenvalue: 1.693 2.383 3.719 1.613 2.865 16.978 6.558

Principal axis factoring with oblimin rotation and Kaiser normalization

N=502

*The item was omitted from further statistical analysis

### References

Agenda, P. (2011). *With their whole lives ahead of them*. New York, NY: Author.

Alansair, M., & Rubie-Davies, C. (2019). What about the tertiary climate Reflecting on five decades of class climate research. *Learning Environments Research*. https://doi.org/10.1007/s10984-019-09288-9

Aldridge, J. M., Fraser, B. J., Bell, L., & Dorman, J. P. (2012). Using a new learning environment questionnaire for reflection in teacher action research. *Journal of Science Teacher Education, 23*(3), 259–290.

Aldridge, J. M., Fraser, B. J., & Huang, I. T. (1999). Investigating classroom environments in Taiwan and Australia with multiple research methods. *Journal of Educational Research, 93*(1), 48–62.

Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*. Wiley.

Bonem, E. M., Fedesco, H. N., & Zissimopoulou, A. N. (2020). What you do is less important than how you do it: The effects of learning environment on student outcomes. *Learning Environments Research, 23*(1), 27–44.

Cuarto, P. M., & Arenillo, S. A. (2015). Classroom climate among teacher education mathematics students. *Asia Pacific Journal of Multidisciplinary Research, 3*(4), 78–85.

Dorman, J. P. (2002). Classroom environment research: Progress and possibilities. *Queensland Journal of Educational Research, 18*(2), 112–140.

Dorman, J. P. (2003). Cross-national validation of the *What Is Happening In this Class? (WIHIC)* questionnaire using confirmatory factor analysis. *Learning Environments Research, 6*(3), 231–245.

Dorman, J. P. (2008). Use of multitrait-multimethod modelling to validate actual and preferred forms of the *What Is Happening In this Class? (WIHIC)* questionnaire. *Learning Environments Research, 11*, 179–197.
Fraser, B. J., Fisher, D. L., & McRobbie, C. J. (1996, April). Development, validation, and use of personal and class forms of a new classroom environment instrument. *Paper presented at the annual meeting of the American Educational Research Association*, New York.

Fraser, B. J. (2012). Classroom learning environments: Retrospect, context and prospect. In B. J. Fraser, K. G. Tobin, & C. J. McRobbie (Eds.), *Second international handbook of science education* (pp. 1191–1239). Springer.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410–8415.

Hair, J. F., Tatham, R. L., Anderson, R. E., & Black, W. (1998). *Multivariate data analysis* (5th ed.). Prentice-Hall.

Hatcher, L. (2013). *Advanced statistics in research: Reading, understanding, and writing up data analysis results*. Shadow Finch Media.

Howell, D. C. (2009). *Statistical methods for psychology* (7th ed.). Cengage Wadsworth.

Institute for College Access and Success. (2020). *Student debt and the class of 2019*. Oakland, CA: Author.

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement*, 20, 141–151.

Khine, M., Fraser, B., Ernest, A., Oo, Z., & Kyaw, T. (2018). Students’ perceptions of the learning environment in tertiary science classrooms in Myanmar. *Learning Environments Research, 21*(1), 135–152.

Khoo, H. S., & Fraser, B. J. (2008). Using classroom psychosocial environment in the evaluation of adult computer application courses in Singapore. *Technology, Pedagogy and Education, 17*(1), 67–81.

Liljedahl, P. (2016). Building thinking classrooms: Conditions for problem-solving. In P. Felmer, E. Pehkonen, & J. Kilpatrick (Eds.), *Posing and solving mathematical problems* (pp. 361–386). Springer.

Lo, C. K., Hew, K. F., & Chen, G. (2017). Toward a set of design principles for mathematics flipped classrooms: A synthesis of research in mathematics education. *Educational Research Review, 22*, 50–73.

McMinn, M., & Aldridge, J. (2020). Learning environment and anxiety for learning and teaching mathematics among preservice teachers. *Learning Environments Research, 23*(3), 331–345.

Meyers, L. S., Gamst, G., & Guarino, A. J. (2006). *Applied multivariate research: Design and interpretation*. Sage Publishers.

Moos, R. H. (1974). *The social climate scales: An overview*. Consulting Psychologists Press.

Moos, R. H., & Trickett, E. J. (1974). *Classroom environment scale: Manual and form*. Consulting Psychologists Press.

Nair, C. S., & Fisher, D. L. (2000). Transition from senior secondary to higher education: A learning environment perspective. *Research in Science Education, 30*(4), 435–450.

Nakagawa, S. (2004). A farewell to Bonferroni: The problems of low statistical power and publication bias. *Behavioral Ecology, 15*(6), 1044–1045.

National Alliance of Concurrent Enrollment Partnerships (NACEP). (2016). Research grant 2016 application guidelines. Retrieved from: http://www.nacep.org/research-policy/research-grants/application-guidelines/

Nunnally, J. C. (1978). *Psychometric theory*. McGraw-Hill.

Program, C. S. L. (2020). *2018–2019 Canada student loans program annual report*. Ottawa, ON: Author.

Skordi, P., & Fraser, B. J. (2018). Validity and use of the What Is Happening In this Class? (WIHIC) questionnaire in university business statistics classrooms. *Learning Environments Research, 22*(2), 1–21.

Skowronek-Ingraffia, C.A. (1986). A study of middle class public and private high schools in relationship to effective schools climate factors. (Unpublished doctoral dissertation). Loyola University, Chicago.

Stein, S., & Klosterman, P. (2020). Nature of learning environment in concurrent enrollment mathematics classrooms: A cluster analysis. *Learning Environments Research, 23*(2), 217–234.

Strayer, J. F. (2012). How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environments Research, 15*(2), 171–193.

Student Loans Company. (2020). Student loans – average loan balance on entry into repayment [Graph of student debt]. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/891524/Average_loan_balance_on_entry_into_repayment_1920.pdf
Trickett, E. J. (1978). Towards a social-ecological conception of adolescent socialization: Normative data on contrasting types of public schools. *Child Development, 49*, 408–414.

Trickett, E. J., & Moos, R. H. (1995). *Classroom Environment Scale: A user manual*. Consulting Psychologists Press Inc.

Valtonen, T., Leppanen, U., Hyypia, M., Kokko, A., Manninen, J., Vartiainen, H., Sointu, E., & Hirsto, L. (2020). Learning environments preferred by university students: A shift toward informal and flexible learning environments. *Learning Environments Research, 23*(3), 1–18.

Walsemann, K. M., Gee, G. C., & Gentile, D. (2015). Sick of our loans: Student borrowing and the mental health of young adults in the United States. *Social Science & Medicine, 124*, 85–93.

Wilkie, C. J. (2000). Preferred college classroom environment scale: Creating positive classroom environments. *Journal of the First-Year Experience, 12*(2), 7–32.

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.