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A Comparison of Online, Video Synchronous, and Traditional Learning Modes for an Introductory Undergraduate Physics Course

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Abstract

While the equivalence between online and traditional classrooms has been well-researched, very little of this includes college-level introductory Physics. Only one study explored Physics at the whole-class level rather than specific course components such as a single lab or a homework platform. In this work, we compared the failure rate, grade distribution, and withdrawal rates in an introductory undergraduate Physics course across several learning modes including traditional face-to-face instruction, synchronous video instruction, and online classes. Statistically significant differences were found for student failure rates, grade distribution, and withdrawal rates but yielded small effect sizes. Post-hoc pair-wise test was run to determine differences between learning modes. Online students had a significantly lower failure rate than students who took the class via synchronous video classroom. While statistically significant differences were found for grade distributions, the pair-wise comparison yielded no statistically significance differences between learning modes when using the more conservative Bonferroni correction in post-hoc testing. Finally, in this study, student withdrawal rates were lowest for students who took the class in person (in-person classroom and synchronous video classroom) than online. Students that persist in an online introductory Physics class are more likely to achieve an A than in other modes. However, the withdrawal rate is higher from online Physics courses. Further research is warranted to better understand the reasons for higher withdrawal rates in online courses. Finding the root cause to help eliminate differences in student performance across learning modes should remain a high priority for education researchers and the education community as a whole.

Keywords Grade distribution · Online · Physics · Withdrawal rate

Introduction

The implementation of technology into higher education classrooms continues to rise. Major universities often offer online options for students and enrollments in online courses are rising (Johnson and Mejia 2014; Online Learning Consortium 2016). Naturally, educators and researchers have been exploring the equivalency of the online and traditional modes of instruction. The significant body of research on the topic has mixed results, with some meta-analysis studies indicating no significant difference between traditional instruction and instruction employing technology while others found significant differences (Allen et al. 2004; Bernard et al. 2004; Cavanaugh et al. 2004; Jahng et al. 2007; Lundberg et al. 2008; Nguyen 2015; Russell 2001; Shachar and Neumann 2003; Sitzmann et al. 2006; Williams 2006; Xu and Jaggars 2013; Zhao et al. 2005).

An important distinction is that student grades have been shown to be equivalent between online and face-to-face courses for students who *complete* online courses; however, students enrolled in an online course are less likely to complete the course (Griffith et al. 2014; Jaggars and Bailey 2010; Jaggars et al. 2013). This is particularly important to consider for underprepared students, who already possess a higher risk for attrition. In contrast, it has been argued that the higher dropout rate for online courses can be attributed to the category of students that opt for online courses (sociological, psychological, technical, and cognitive factors), rather than attributing the withdrawal/failure rate to the medium itself (Howell et al. 2004; Tyler-Smith 2006). This withdrawal rate has been attributed to cognitive overload and has been correlated to prior performance in college classes (Cochran et al. 2014; Tyler-Smith 2006). A study of enrollments in California's

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community college system supported the decrease in student outcomes in an online versus traditional course format (Johnson and Mejia 2014). However, looking at a longer timeline revealed that learners who completed at least a few online courses were more likely to complete an associate's degree or to transfer to a 4-year institution.

Online education can be offered synchronously and asynchronously through various media. Sitzmann et al. (2006) found no statistically significant difference in student performance based on the delivery media (Sitzmann et al. 2006). A meta-analysis completed by the U.S. Department of Education found that student learning outcomes in hybrid-online and online courses were equal to or better than traditional courses, with the positive effect more pronounced in the hybrid course compared to traditional than for online compared to traditional (Means et al. 2009).

The quality of online coursework has been scrutinized in the literature. In some cases, in-class content is simply inserted into an online format without concern for best practices for the online modality (Cox 2005). Students report lower level of instructor presence in online courses, which can result in the mindset that they have to "teach themselves" (Bambara et al. 2009; Jaggars 2014). Alternatively, research has suggested that the online environment promotes studentcentered learning that is less intimidating and encourages participation and more meaningful interactions (Karayan and Crowe 1997; Ni 2013; Warschauer 1997). A 2002 meta-analysis found that students marginally prefer traditional format over distance education (Allen et al. 2002). Students also report preference for "easier" classes online and "harder" classes in a traditional format (Jaggars 2014). An interesting and poorly documented phenomenon is "course shopping" where students enroll in multiple online courses and select one to complete, dropping the others within the add/drop window to receive a refund (Hagerdorn et al. 2007).

Hundreds of studies exist that compare traditional and online modalities. However, very limited research is available to compare these two approaches for college-level introductory Physics. Two studies comparing traditional and online homework in introductory physics had conflicting results, with one study failing to reveal significant differences between the medium and student learning and the other indicating a statistically significant gain in the student learning outcomes in the online format (Bonham et al. 2003; Cheng et al. 2004). A study of modifying a traditional undergraduate Physics class to include a hybrid component showed positive student opinions regarding the online interaction (Martin-Blas and Serrano-Fernandez 2009).

Only one study was found that compared the whole course in the online versus the traditional format. In a comparison of community college science classes (including Physics), students enrolled in the online courses typically had a higher GPA and more credit hours but the traditional course resulted in a higher average grade in the course (Colorado Department of Higher Education 2012). However, when isolating the Physics data, there was no significant difference in grades for students enrolled in online versus traditional classes. The authors believe these differences are open to interpretation and suggest future research.

The purpose of this study was to critically compare student performance in online and traditional undergraduate introductory Physics classes. This comparison will include course completion (withdrawal and failure rates) and grade distribution. We are seeking evidence to support the following hypotheses:

Ha_1. Failure rates in classroom, online, and video synchronous learning modes are not equivalent for introductory undergraduate Physics students.

Ha_2. Grade distribution in classroom, online, and video synchronous learning modes are not equivalent for introductory undergraduate Physics students.

Ha_3. Student withdrawal rates were not equally distributed between the four learning modes for introductory undergraduate Physics students.

Methods

Theoretical Framework

With growing enrollments in non-traditional distance classrooms, the majority of college administrators recognize distance learning as key to their long-term strategic goals (Allen and Seaman 2013). As more students opt for online or synchronous video courses, the natural question to ask is if the effectiveness of the educational experience with distance learning formats is equivalent to what students experienced in traditional face-to-face "lecture" classes.

Previous meta-analysis work attempted to measure differences between lecture and distance learning format (Bernard et al. 2004; Hrastinski 2008; Means et al. 2009). The results of the three meta-analyses above mostly indicated either no significant difference or offered support for distance learning. However, the importance of student engagement was also a common theme in the literature (Lou et al. 2006; Martin and Parker 2014). At the university under study in this report, two separate studies noted some differences in student performance by modality (Dunn 2013; Griffith et al. 2014). However, these studies did not specifically examine Physics courses nor did the authors explore student engagement.

The failure and withdrawal rates as well as grade distributions were examined as the most overt indicators of student performance. The research used a retrospective quantitative research design to evaluate the aggregate data. Data were treated as nominal and tested non-parametrically using chi-square at $\alpha = .05$. Data were reviewed with any ambiguous results clarified before being evaluated with the statistic (Gay et al. 2006).

Participants

Embry-Riddle Aeronautical University (ERAU) is a medium sized university with a selectivity rating of "selective" according to the U.S. News and World Report (U.S. News and World Report 2017). ERAU is ranked number 1 in Best Online Bachelor's Programs (U.S. News and World Report 2017). {University Name} is ranked number {insert number here} in Best Online Bachelor's Programs {insert citation here}. This university had an 80–20% mix of lecture to distance learning classes in 2007. However, in 2017, the projected numbers are flipped, with 15% of classes meeting in a traditional lecture modality while 85% are non-traditional modalities, including asynchronous online, at home synchronous video, or on campus synchronous video.

Aggregate data containing 1964 student grades were mined from ERAU Campus Dashboard for the time period August 2015 to July 2016 for PHYS 102 - Explorations in Physics, an introductory algebra-based undergraduate Physics course. The course includes ten experiments hosted on the WebAssign platform. This course was chosen because it had a robust mix of enrollments in multiple modalities: traditional in-person classroom, synchronous video online, and asynchronous online. The course is required for a variety of Bachelor of Science degrees: Aeronautics, Aviation Maintenance, Aviation Security, Safety Management, and Unmanned Systems. The course is also a physical science elective option for numerous degree programs, including emergency services, homeland security, logistics, communication, interdisciplinary studies, project management, and technical management.

All courses were taught in a 9-week format. Online semester lengths vary by institution from the traditional 15-week semester to as short as 5 weeks; 8-week semesters are common. Traditional in-person classes met one time per week for 3 h and 20 min with another 90 min of asynchronous online engagement outside of class time (primarily through discussion boards) or were taught for 4 h and 45 min one time per week with no online component. Synchronous video learning courses also met one night per week for the same amount of time. Students and instructors alike used a webcam and microphone. Students could see the instructor and the slides presented, shared documents, or whiteboard being used. Students could also ask questions via chat or by audio as well as make presentations when enabled by the faculty. Video synchronous instruction was used in two learning modes: (1) synchronous video home where faculty and students were at home and met one time a week for class and (2) synchronous video classroom where multiple classrooms from various remote locations were linked together. The final learning mode examined in this study was online which used the same 9-week format but conducted asynchronously throughout.

Students enrolled in the studied sections were primarily non-traditional students. Most worked full time and 50% were affiliated with the U.S. military. The average age was 34 years old. Faculty had a master's degree or doctorate in Physics. At least 25% of courses taught were by doctoral level faculty. Faculty completed training courses in the history and culture of the university, how to teach online courses, and had to complete additional courses to teach in video synchronous formats.

Procedure

In this study, the independent variable was the course modality with four categories: in-person (traditional), synchronous video classroom, synchronous video home, and asynchronous online. The dependent variables measured were student failure rate, grade distribution, and student withdrawal rate. The influence of moderating variables was reduced because the data was obtained from one institution, and the various modalities of the course all operated from the same master course outline, ensuring consistent learning outcomes. Additionally, the courses used a template that kept the majority of assignments consistent across modalities.

The three hypotheses were tested using chi-square test ($\alpha = .05$) at the appropriate degrees of freedom (Gay et al. 2006). The hypotheses Ha_1 and Ha_2 concerning failure rates and grade distribution used a subset of the entire data file ($n = 1909$). The hypothesis Ha_3 concerning withdrawal rates included data on the additional 55 students who withdrew from Physics classes ($n = 1964$). All data were aggregate with no individual identification of students to ensure student confidentiality. Data used in this analysis was obtained from Aug 2015 to July 2016.

Descriptive statistics between modalities for the Physics classes are presented in Tables 1, 4, and 6. To evaluate each hypothesis, the appropriate chi-square test ($\alpha = .05$) was performed to identify statistically significant differences based on learning mode (Table 2). Furthermore, post-hoc statistical tests compared learning modes pair-wise (Tables 3, 5, and 7) (Gay

Table 1 Pass and failure rates based on learning modes ($n = 1909$)

Learning mode	F	P	Total
Synchronous video home	5 (3.2%)	152 (96.8%)	157
Synchronous video classroom	26 (8.1%)	297 (92.0%)	323
In-person	10 (9.0%)	101 (91.0%)	111
Online	53 (4.0%)	1265 (96.0%)	1318
Total	94 (4.9%)	1815 (95.1%)	1909

Data does not include student withdrawals

Table 2 Chi-square contingency table for hypotheses ($\alpha = .05$)

Variable	DF	Value	p value	Cramer's V
Failure rate	3	14.005393	0.0029	.08565
Grade distribution	12	29.3227	0.0035	.07155
Withdrawal rate	3	14.317739	0.0025	.08538

et al. 2006). These multiple pair-wise tests used the Bonferroni correction to avoid type one errors (.00833). This alpha level was determined by dividing .05 by 6 reflecting the number of multiple comparisons done on each hypotheses. Effect sizes were also calculated using the Cramer's V statistic. Data were tested using StatCrunch Data Analysis on the Web and StatDisk (Triola 2013).

Results

Overall, 95% of all students who took introductory Physics passed the course. Students who took the course through the synchronous video home course passed at a 96.8% rate which was followed closely by students who took the course online (95.98%). Students who took the course in-person passed at the lower rate of 90.99%. Synchronous video classroom students passed at a slightly higher rate of 91.95%.

The Chi-Square Analysis (Table 2) indicated a statistically significant difference in the proportions of failure rate between learning mode. In particular, students who attended introductory Physics via synchronous video home and online had a significantly lower failure rate than students who took the course via in-person or synchronous video classrooms.

Each learning mode was then compared against the other learning modes in a series of post-hoc pair-wise comparisons evaluated by the more conservative Bonferroni adjustment ($\alpha = .00833$ shown in Table 3). The online failure rate was significantly different (lower) than the synchronous video classroom rate (.0024). However, this result also had a very small effect size ($V = .07482$). The remaining mode comparisons yielded non-significant results, indicating similarity in failure rate. Pair-wise comparisons were evaluated using chi-square test and re-evaluated using Fisher's exact test if a low cell warning was indicated (Triola 2013).

The second hypothesis concerned the grade distributions. The authors believed the grade distributions would not be equivalent between the four learning modes. Descriptive data are shown in Table 4. Overall, 34.05% of introductory Physics students earned an A, 41.85% earned a B, 16.71% earned a C, almost 2.46% earned a D, and slightly fewer than 5% failed the course. The distribution of As differs between the four learning modes from a high of 35.05% for online students to a low of 24.02% for students who took the course in person. Students who took the course via synchronous video home earned the highest percentage of Bs. In-person classroom students earned the highest percentage of Cs. Recall that the failure rate for synchronous video home and online students was less than in-person classroom and synchronous video classroom.

The chi-square analysis (Table 2) indicated that there is a statistically significant difference in the distribution of student grades between learning modality. Students who took online or synchronous video classroom tended to get more As. Students who took synchronous video home or online courses earned a higher percentage of Bs. Students who took in-person or synchronous video classroom courses tended to earn more Fs.

Each learning mode was compared against the other learning modes in a series of post-hoc pair-wise comparisons evaluated by the more conservative Bonferroni adjustment ($\alpha = .00833$ shown in Table 5). Mode comparisons yielded non-significant results and very small Cramer's V effect size values indicating similarity in grade distributions (Triola 2013).

The third hypothesis investigated the difference in the proportions of withdrawal rate between the four learning modes. The overall withdrawal rate from the Physics classes was 2.8% while students who took introductory Physics online

Table 3 Chi square post-hoc results: failure rate ($\alpha = .00833$)

	DF	Value	p value	Cramer's V
Synchronous video home versus in-person classroom	1	4.1748	.0410	.12481
Synchronous video home versus synchronous video classroom	1	4.1388	.0419	.09286
Synchronous video home versus online	1	0.2599	.6102	.01327
Online versus synchronous video classroom	1	9.1867	.0024	.07482
Online versus in-person Classroom	1	6.0435	.0140 (Fisher's exact test .0256)	.06503
In-person versus synchronous video classroom	1	1	.7519	.01518

One of the chi-square tests showed the following warning: over 20% of cells had an expected count less than 5. Fisher's exact test results are shown in parentheses following the chi-square result

Table 4 Grade distribution by modality ($n = 1909$)

	A	B	C	D	F	Total
Synchronous video home	48 (30.6%)	69 (44.0%)	26 (16.6%)	9 (5.7%)	5 (3.2%)	157
Synchronous video classroom	113 (35.0%)	124 (38.4%)	55 (17.0%)	5 (1.6%)	26 (8.1%)	323
In-person	27 (24.3%)	46 (41.4%)	24 (21.6%)	4 (3.6%)	10 (9.0%)	111
Online	462 (35.0%)	560 (42.5%)	214 (16.2%)	29 (2.2%)	53 (4.0%)	1318
Total	650 (34.1%)	799 (41.9%)	319 (16.7%)	47 (2.5%)	94 (4.9%)	1909

Data does not include student withdrawals

withdrew at a 3.65% rate, the highest of the four learning modes (Table 6). Synchronous video home had the second highest percentage (2.48%) followed by synchronous video classroom (0.31%) while in-person classroom courses had no withdrawals.

The chi-square test to determine the significance of these differences indicated a statistically significant difference in withdrawal rates across the learning modes (Table 2). Students who took introductory Physics in-person and via synchronous video classroom learning modes experienced a lower withdrawal rate than students who took the course via other modes.

In a post-hoc pairwise comparison ($\alpha = 0.00833$), the withdrawal rate from synchronous video home was higher than that from the synchronous video classroom but was not statistically significant (0.0255) (Table 7). Synchronous video home had four withdrawals and the synchronous video classroom data had one. The statistical result could have been compromised by the low frequency counts. The synchronous video home rate comparison with the in-person classroom yielded a non-significant finding. In-person classes had no withdrawals compared to four for synchronous video home. The data analysis may have been compromised by the low expected frequencies for withdrawals in the synchronous video home and in-person classroom comparison. The online withdrawal rate was also higher than both the synchronous video classroom (.0015) and in-person rates (.0404). Only the online versus synchronous video classroom pair-wise test yielded statistical significance after the Bonferroni correction was applied. It should be noted however that the Cramer's V effect size value was small. The remaining mode comparisons yielded non-significant results; however, the comparison between in-person and synchronous video classroom could have been impacted by low expected frequency counts. (Triola 2013).

Discussion

Hypothesis Testing

All alternative hypotheses were supported by the statistical analysis in this study. Overall, student failure rates, grade distribution, and withdrawal rates were to a statistically significant degree related to the learning mode students chose when taking introductory Physics. Effect sizes on all significant findings were very small. Students who took the course online passed their classes at a higher rate (lower percentage of failing grades) than students who took the course via synchronous video classroom. This difference was significant even when using the more conservative Bonferroni corrected alpha of .00833. In online modes, students may feel more of a one on one relationship with the course materials and instructors than in synchronous video classroom situations or may simply be more comfortable with the asynchronous online format.

The grade distribution for all modes of instruction yielded As or Bs for 76% of all students who took the Physics course. This rate is higher than what is found at many universities. This high rate of As and Bs may be due to the nontraditional student population. Approximately 50% of the students in this

Table 5 Chi-square post-hoc results: grade distribution ($\alpha = .00833$)

	DF	Value	p value	Cramer's V
Online versus synchronous video classroom	4	10.4221	.0339	.07969
Synchronous video home versus in-person	4	5.8393121	.2115	.11599
Online versus in-person	4	11.9028	.0181	.09127
Synchronous video home versus in-person	4	6.4440693	.1683	.15506
Synchronous video home versus online	4	7.9370171	.0939	.07336
Synchronous video home versus synchronous video classroom	4	11.6525	.0201	.15581

Table 6 Student withdrawals by modality ($n = 1964$)

	Complete	Withdraw	Total
Synchronous video home	157 (97.52%)	4 (2.48%)	161
Synchronous video classroom	323 (99.69%)	1 (0.31%)	324
In-person	111 (100%)	0 (0%)	111
Online	1318 (96.35%)	50 (3.65%)	1368
Total	1909 (97.2%)	55 (2.8%)	1964

study were associated with the U.S. military and are required to get a C or above grade or lose reimbursement for the course. Overall, the grade distributions and learning mode appeared to be related at $\alpha = .05$ level of significance. However, the effect size of this finding was very small. The post-hoc pair-wise comparisons yielded no statistically significant differences between the learning modes when using the Bonferroni corrected alpha of .00833. The grade distributions for students who took introductory Physics via online were different than synchronous video classroom and in-person classroom learning modes, and the distribution for synchronous video home students differed from synchronous video classroom students but only to an alpha of .05. Once the Bonferroni correction was applied, these findings were not statistically significant. The remaining mode comparisons yielded non-significant results (at either $\alpha = .05$ or after the Bonferroni correction) meaning similarity in grade distributions. In this study, online students received a higher percentage of As than all other modes examined. Synchronous video home students earned a higher percentage of Bs and a lower percentage of Fs than other modes.

The last hypothesis examined yielded some curious results when compared to the first two hypotheses. Student withdrawal rates were lowest for students who took in-person and synchronous video classrooms than the other two modes of learning. This possibly could be related to visible peer support when in a traditional or synchronous video classroom environment. In each of these learning modes, students can more easily sense a presence of their peers. It is interesting to note that in-person and synchronous video classroom students withdrew at 0 and 0.31% rates respectively, much lower than online (3.65%) where students attend class on their own without the direct presence of peers.

Limitations of This Study

There are five major limitations to address in this study. First, the statistical analysis of the data with respect to the third hypothesis is weakened by low counts. Specifically, over 20% of cells for withdrawal rate had an expected count less than 5, a violation of the assumptions for the chi-square test. Researches used Fisher's exact test in those cases to show the relationship in those cases.

The second limitation was small effect sizes. Researchers attempted to use conservative alpha values to avoid type I errors, particularly with the post-hoc pair-wise comparisons. However, low effect sizes were present in all significant findings. This should be taken into account when drawing conclusions from this research.

Another limitation of this study is the inability to fully control all moderating variables. The pedagogical choices and teaching style of an instructor is known to have an influence on student success and persistence in a course. This study used enrollments from a specific campus of a single university. The course chosen operated from a Master Course Outline and each modality of the course is taught from a template. While this reduces variability, it is impossible to completely control the influence of the instructor on the dependent variables measured in this study.

The fourth limitation is faculty teaching each of the four modes of instruction, in terms of highest degree attained and years of teaching experience. All faculty had either a master's degree or doctorate in Physics or related discipline. The years of service inevitably varies.

The last limitation is that this study did not control for age when evaluating the hypotheses. The university campus under study was a non-traditional campus with an average student age of 34. Students either took class at night, on weekends, or online. Approximately 50% of the student body were active duty military personnel. This contrasts sharply with the

Table 7 Chi-square post-hoc results: withdrawals ($\alpha = .05$)

	DF	Value	*p* value	Cramer's V
Synchronous video home versus synchronous video classroom	1	4.9906	.0255 (Fisher's exact test .0437)	.10144
Synchronous video home versus in-person	1	2.7989246	.0943 (Fisher's exact test .1477)	.10144
Synchronous video home versus online	1	.057926269	.4466	.01946
Synchronous video classroom versus in-person	1	.034338198	.5579 (Fisher's exact test 1)	.0281
Online versus synchronous video classroom	1	10.0344	.0015	.07701
Online versus in-person	1	4.1990	.0404 (Fisher's exact test .289)	.05328

Four of the chi-square tests showed a the following warning: over 20% of cells had an expected count less than 5. Fisher's exact test results are shown in parentheses following the chi-square result “typical” university with most undergraduate students between the ages of 18 and 22.

Conclusions

In this study, students that persist in an online introductory Physics class are more likely to achieve an A than in other modes. However, the withdrawal rate is higher from online introductory Physics courses. Future research should consider variables such as age and gender. An interesting phenomenon was uncovered where students enrolled in an environment where there is a visible peer support were less likely to withdraw from the course. This warrants further research into the reasons students withdraw from a course to determine if these reasons are shaped by the modality of the course. A focused survey could help identify trends as to why students make the decision to remove themselves from a course.

Compliance with Ethical Standards

The authors declare that they have no conflict of interest.

This research was reviewed by the institution Internal Review Board and deemed exempt. Therefore, informed consent was not required for this study.

References

Allen, I. E., & Seaman, J. (2013). *Changing course: ten years of tracking online education in the United States*. Newburyport: Sloan Consortium.

Allen, M., Bourhis, J., Burrell, N., & Mabry, E. (2002). Comparing student satisfaction with distance education to traditional classrooms in higher education: A meta-analysis. *American Journal of Distance Education, 16*(2), 83–97. https://doi.org/10.1207/S15389286AJDE1602_3.

Allen, M., Mabry, E., Mattrey, M., Bourhis, J., Titsworth, S., & Burrell, N. (2004). Evaluating the effectiveness of distance learning: A comparison using meta-analysis. *The Journal of Communication, 54*(3), 402–420. https://doi.org/10.1111/j.1460-2466.2004.tb02636.x.

Bambara, C. S., Barbour, C. P., Davies, T. G., & Athey, S. (2009). Delicate engagement: The lived experience of community college students enrolled in high-risk online courses. *Community College Review, 36*(3), 219–238. https://doi.org/10.1177/0091552108327187.

Bernard, R. M., Abrami, P. C., Lou, Y., Borokhovski, E., Wade, A., Wozney, L., Wallet, P. A., Fiset, M., & Huang, B. (2004). How does distance education compare with classroom instruction? A meta-analysis of the empirical literature. *Review of Educational Research, 74*(3), 379–439 Retrieved from http://www.jstor.org/stable/3516028.

Bonham, S., Deardorff, D., & Beichner, R. (2003). Comparison of student performance using web and paper-based homework in college-level physics. *Journal of Research in Science Teaching, 40*(10), 1050–1070. https://doi.org/10.1002/tea.10120.

Cavanaugh, C., Gillan, K. J., Kromrey, J., Hess, M., & Blomeyer, R. (2004). The effects of distance education on K-12 student outcomes: A meta-analysis. Learning point associates/north central regional educational laboratory. Retrieved from https://eric.ed.gov/?id=ED489533

Cheng, K. K., Thacker, B. A., Cardenas, R. L., & Crouch, C. (2004). Using an online homework system enhances students’ learning of physics concepts in an introductory physics course. *American Journal of Physics, 72*(11), 1447–1453. https://doi.org/10.1119/1.1768555.

Cochran, J., Campbell, S. M., Baker, H. M., & Leeds, E. M. (2014). The role of student characteristics in predicting retention in online courses. *Research in Higher Education, 55*(1), 27–48. https://doi.org/10.1007/s11162-013-9305-8.

Colorado Department of Higher Education. (2012). *Online versus traditional learning: a comparison study of colorado community college science classes.* Colorado Department of Higher Education. Retrieved from http://wcet.wiche.edu/sites/default/files/1622CCCSOnlinevsTraditionalScienceStudyReportJune2012update.pdf. Accessed 12 Jan 2018.

Cox, R. D. (2005). Online education as institutional myth: Rituals and realities at community colleges. *Teachers College Record, 107*(8), 1754–1787 Retrieved from https://pdfs.semanticscholar.org/8536/f69281bb6d720e96b8e76d4aa58c146ea9a7.pdf.

Dunn, L. (2013). *A study to compare and contrast student grades and satisfaction levels of traditional classroom and distance learning environments at embry-riddle aeronautical university worldwide campus.* Unpublished master’s degree graduate capstone project. Daytona Beach: Embry-Riddle Aeronautical University, Worldwide Campus.

Gay, L. R., Mills, G. E., & Airasian, P. W. (2006). *Educational research: Competencies for analysis and applications* (8th ed.). Upper Saddle River, New Jersey: Pearson Education, Inc..

Griffith, J., Roberts, D., & Schultz, M. (2014). Relationship between grades and learning mode. *Journal of American Business Review, 3*(1), 81–88.

Hagerdorn, L. S., Maxwell, W. E., Cypers, S., Moon, H. S., & Lester, J. (2007). Course shopping in urban community colleges: an analysis of student drop and add activities. *The Journal of Higher Education, 78*(4), 464–485.

Howell, S. L., Laws, R. D., & Lindsay, N. K. (2004). Reevaluating course completion in distance education. *Quarterly Review of Distance Education, 5*(4), 243–252.

Hrastinski, S. (2008). Asynchronous and synchronous e-learning. *Educause Quarterly, 31*(4), 51–55 Retrieved from http://er.educause.edu/articles/2008/11/asynchronous-and-synchronous-elearning.

Jaggars, S. S. (2014). Choosing between online and face-to-face courses: Community college student voices. *American Journal of Distance Education, 28*(1), 27–38. https://doi.org/10.1080/08923647.2014.867697.

Jaggars, S. S., & Bailey, T. (2010). *Effectiveness of fully online courses for college students: response to a department of education meta-analysis.* Community college research center. Retrieved from http://ccrc.tc.columbia.edu/publications/effectiveness-fully-online-courses.html. Accessed 12 Jan 2018.

Jaggars, S. S., Edgecombe, N., & Stacey, G. W. (2013). *What we know about online course outcomes.* Columbia University: Community College Research Center. Retrieved from https://eric.ed.gov/?id=ED542143. Accessed 12 Jan 2018.

Jahng, N., Krug, D., & Zhang, Z. (2007). Student achievement in online distance education compared to face-to-face education. *European Journal of Open, Distance, and E-Learning,*. Retrieved from http://www.eurodl.org/materials/contrib/2007/Jahng_Krug_Zhang.htm.

Johnson, H. P., & Mejia, M. C. (2014). *Online learning and student outcomes in California’s community colleges.* Public Policy Institute of California. Retrieved from http://www.ppic.org/content/pubs/report/R_514HJR.pdf. Accessed 8 Dec 2017.

Karayan, S., & Crowe, J. (1997). Student perspectives of electronic discussion groups. *The Journal: Technological Horizons in Education, 24*(9), 69–71 Retrieved from https://eric.ed.gov/?id=EJ543201.

Lou, Y., Bernard, R. M., & Abrami, P. C. (2006). Media and pedagogy in undergraduate distance education: A theory-based meta-analysis of empirical literature. *Educational Technology Research and Development, 54*(2), 141–176. https://doi.org/10.1007/s11423-006-8252-x.

Lundberg, J., Castillo-Merino, D., & Dahmani, M. (2008). In Castillo-Merino D., &Sjoberg M. (Eds.), *Do online students perform better than face-to-face students? reflections and a short review of some empirical findings* (1st ed.) Editorial UOC. Retrieved from http://www.uoc.edu/rusc/5/1/dt/eng/lundberg_castillo_dahmani.pdf. Accessed 8 Dec 2017.

Martin, F., & Parker, M. A. (2014). Use of synchronous virtual classrooms: Why, who, and how? *Journal of Online Learning and Teaching, 10*(2), 192.

Martin-Blas, T., & Serrano-Fernandez, A. (2009). The role of new technologies in the learning process: moodle as a teaching tool in physics. *Computers in Education, 52*(1), 35–44. https://doi.org/10.1016/j.compedu.2008.06.005.

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2009). *Evaluation of evidence-based practices in online learning: a meta-analysis and review of online learning studies*. Washington, D.C.: U.S. Department of Education.

Nguyen, T. (2015). The effectiveness of online learning: beyond no significant difference and future horizons. *Journal of Online Learning and Teaching, 11*(2), 309–319 Retrieved from http://jolt.merlot.org/Vol11no2/Nguyen_0615.pdf.

Ni, A. Y. (2013). Comparing the effectiveness of classroom and online learning: teaching research methods. *Journal of Public Affairs Education, 9*(2), 199–215 Retrieved from http://www.jstor.org/stable/23608947?seq=1#page_scan_tab_contents.

Online Learning Consortium. (2016). Babson study: distance education enrollment growth continues. Retrieved from https://onlinelearningconsortium.org/news_item/babson-study-distance-education-enrollment-growth-continues-2/

Russell, T. (2001). *The no significant difference phenomenon: as reported in 355 research reports, summaries, and papers* (5th ed.). North Carolina State University: IDECC.

Shachar, M., & Neumann, Y. (2003). Differences between traditional and distance education academic performances: a meta-analytic approach. *The International Review of Research in Open and Distributed Learning, 4*(2), 1–20 Retrieved from http://www.irrodl.org/index.php/irrodl/%20article/viewArticle/153/234.

Sitzmann, T., Kraiger, K., Steward, D., & Wisher, R. (2006). The comparative effectiveness of web-based and classroom instruction: a meta-analysis. *Personnel Psychology, 59*(3), 623–664. https://doi.org/10.1111/j.1744-6570.2006.00049.x.

Triola, M. (2013). Statdisk Pearson Education Inc. Retrieved from http://www.statdisk.org/

Tyler-Smith, K. (2006). Early attrition among first time eLearners: a review of factors that contribute to drop-out, withdrawal, and non-completion rates of adult learners undertaking eLearning programmes. *Journal of Online Learning and Teaching, 2*(2), 73–85 Retrieved from http://jolt.merlot.org/index.html.

U.S. News and World Report. (2017). Embry-riddle aeronautical university. Retrieved from https://www.usnews.com/best-colleges/embry-riddle-1479. Accessed 12 January 2018.

Warschauer, M. (1997). Computer-mediated collaborative learning: theory and practice. *The Modern Language Journal, 81*(4), 470–481.

Williams, S. L. (2006). The effectiveness of distance education in allied health science programs: a meta-analysis of outcomes. *American Journal of Distance Education, 20*(3), 127–141. https://doi.org/10.1207/s15389286ajde2003_2.

Xu, D., & Jaggars, S. S. (2013). The impact of online learning on students' course outcomes: evidence from a large community and technical college system. *Economics of Education Review, 37*, 46–57. https://doi.org/10.1016/j.econedurev.2013.08.001.

Zhao, Y., Lei, J., Yan, B., Lai, C., & Tan, H. S. (2005). What makes the difference? A practical analysis of research on the effectiveness of distance education. *Teachers College Record, 107*(8), 1836–1884.