5-2024

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Routledge
Taylor & Francis Group

Open Learning: The Journal of Open, Distance and e-Learning

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/copl20

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To cite this article: Emily Howell, Sandra Linder, Joseph Ryan & William C. Bridges (14 May 2024): Examining higher education through HyFlex, Open Learning: The Journal of Open, Distance and e-Learning, DOI: 10.1080/02680513.2024.2354245

To link to this article: https://doi.org/10.1080/02680513.2024.2354245

Published online: 14 May 2024.

OPEN LEARNING: THE JOURNAL OF OPEN, DISTANCE AND E-LEARNING
https://doi.org/10.1080/02680513.2024.2354245

Examining higher education through HyFlex

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ABSTRACT

This design-based research (DBR) study investigated the following research question: How can the HyFlex instructional model be leveraged to create more accessible and equitable education for graduate students? To address this question, the researchers explored two education doctoral courses in the USA, with 37 participants for one semester. The essential elements of the intervention included the following: digital, multimodal tools; equity of online and face-to-face learning environments; and engagement in community. A mixed methods approach to data collection and analysis was utilised in accordance with the DBR framework, including inhibiting and enhancing factors of the intervention, modifications made, unanticipated outcomes, and progress towards the goal. The discussion provides guidance for future implementation of the HyFlex model in higher education.

ARTICLE HISTORY
Received 8 November 2022
Accepted 18 April 2024

KEYWORDS
HyFlex; higher education; design-based research; graduate education; online

The COVID-19 pandemic reinforced the need for flexibility within the world of higher education, comprised of institutions that have traditionally been extremely rigid regarding their policies and procedures despite being the home of liberal-minded academics (Chandler, 2013). This need for change was highlighted by The Public Policy Institute of California showing that the pandemic exacerbated the pre-existing inequalities within higher education, negatively impacting students from underrepresented groups, including students from lower socioeconomic status (SES) and people of colour (Johnson et al., 2022). For instance, community colleges experienced significant declines in enrolment among Black, Native American, and Latino students who were all highly underrepresented groups on campus. These trends have troubling future impact as leaders fear a widening in the racial income gap if fewer underrepresented graduates with higher education degrees enter the labour market (Zerbino, 2021). To meet the demands of the changing needs of students, online learning took an increased precedence which is likely to continue in the context of higher education. Hybrid models, such as HyFlex, which enable multiple modes of instruction, hold promise by offering students and higher education flexibility and providing increased capacity to reach students not traditionally served by these institutions. Yet, the quality of this education, while promising in equitable student outcomes (Binnewies & Wang, 2019; Calafiore & Giudici, 2021), still needs

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further study, especially as it relates to the equitable engagement of these students (Mentzer et al., 2023).

This study took place at a top-tier research, land-grant, public university in the USA that adopted HyFlex graduate learning during the fall of 2021 to increase (a) graduate enrolment, (b) diversity of the student population, and (c) online instructional options. This design-based research (DBR) study examined this transition with the goal of understanding how to leverage the HyFlex model of education towards more accessible, equitable education. Through mixed methods of data collection and analysis in two doctoral courses, we examined an intervention focusing on the following essential elements: digital, multimodal tools; equity of online and face-to-face learning environments; and engagement in community.

Perspectives

HyFlex is a term that derives from hybrid or blended learning, with online components, typically not exceeding 50% of class time, supporting face-to-face learning (Calafiore & Giudici, 2021). However, HyFlex, coined by Beatty (2019) for course design at San Francisco State University in 2006, accentuates the flexibility in these hybrid environments in which the significance of this term derives from the agency given to students to choose which mode of learning they desire on a class-by-class basis. This modality may include face-to-face instruction and online instruction, provided in either a synchronous or asynchronous manner. Lakhal et al. (2017, p. 50) described how this flexibility may increase access: 'Blended synchronous course delivery mode provides students with greater educational access as it responds to students' scheduling needs by offering flexibility in course attendance.' Raes et al. (2020) described how such flexibility may appeal to an increasingly diverse student population with ever-expanding demands outside the classroom (Malczyk, 2019; Miller et al., 2013). Researchers have noted institutional successes with the HyFlex model, which includes increased student enrolment, less human and infrastructure investment, and consolidation of costs (Lakhal et al., 2017; Wang et al., 2017). Further, the literature also discusses potential benefits to students. Research has noted successes for students such as increased flexibility (Binnewies & Wang, 2019) without negatively impacting student grades (Binnewies & Wang, 2019; Calafiore & Giudici, 2021; Miller et al., 2013). However, these benefits were not without cost, such as requiring professional development for faculty (Abdelmalak & Parra, 2016). Other challenges to HyFlex instruction include reduced social interaction for students. While high interaction rates were observed within groups of online and face-to-face participants, fewer interactions were observed between these groups (Stewart et al., 2011). However, students valued the perspectives gained by bringing together more diverse backgrounds than their typical classrooms. Thus, HyFlex offers a worthwhile goal for making education more accessible through its inherent flexibility, though this modality currently lacks research regarding its implementation (Howell, 2022). For example, in Howell's (2022) literature review of HyFlex, she found the largest theme related to defining this term, whereas its course design and enaction needed nuance especially related to how this instruction differs from and is not an addendum to traditional instruction. The present study investigated the goal of leveraging HyFlex education for accessible, equitable

education to address this gap and answer the first question of the DBR framework: What is a justifiable pedagogical goal, supported by research and theory (Bradley & Reinking, 2011)?

Literature review: the intervention

In DBR, researchers study an intervention towards an educational goal and make modifications to the intervention as needed by studying enhancing and inhibiting factors. With a research method often in flux as the research team responds to these factors, one way of establishing fidelity is to be mindful of what components define the intervention, which can be enacted in a myriad of ways, but if missing would change the fundamental identity of the intervention (Howell et al., 2017, 2021; Reinking & Bradley, 2008). These essential elements must be justified by the research literature and answer the second question of the DBR framework: What intervention has potential to reach this goal (Bradley & Reinking, 2011; Reinking & Bradley, 2008)? The essential elements of this intervention include the following: digital, multimodal tools; equity of online and face-to-face learning environments; and engagement in community. Subsequently, we address how they were included in the intervention and the justification for doing so.

Digital, multimodal tools

Several literacy theories have acknowledged why digital tools and the concept of literacy, and therefore the building blocks of content-area instruction, must be integrated (Howell et al., 2021). Cazden et al. (1996) discussed the notion that as society becomes increasingly digital as well as interconnected, literacy will not just be limited to the alphabetic text that was dominant in the conventional notion of literacy but will include the multiple modes or forms of expression more immediately afforded in digital tools. They coined the term for this form of multimodal literacy: *multiliteracies*. Further, Jenkins (2009) noted skills needed for what he termed *new media literacy*, which included traditional skills of reading and writing but elaborated on the social, connected nature of thinking skills in environments increasingly linked through digital environments.

Specifically connecting the use of these digital, multimodal tools with HyFlex learning environments, their use must be considered in the fundamental instructional design of such courses according to Beatty (2019), especially principles of equivalency and accessibility. Equivalency speaks to the notion that learning activities lead to similar learning outcomes, while accessibility relates to students' ability to use these tools towards their learning. Further, in the 2022 EDUCAUSE Horizon Report on teaching and learning, which focuses on current and future influences in higher education, the authors found hybrid and online learning to be a large, social macro trend impacting higher education (Pelletier et al., 2022). Further, this report found hybrid learning spaces to be a key technology practice, having a significant influence and thus warranting additional study.

In this study, students were enrolled in a course hosted through the Canvas learning management system and could attend classes face-to-face or online through the Zoom conferencing system. Instruction was provided on campus in classrooms outfitted with a camera, microphone, speakers, and projector. This essential element and the others described subsequently were each discussed in monthly observations and research team

meetings, as to whether they were inhibiting or enhancing the intervention as well as whether they should be modified.

Equity of online and face-to-face learning environments

The notion of equity and technology has been of concern since the advent of technology itself. In the 1990s, there was concern of a digital divide between those who had access to technology and those who did not. As access has widened, further concerns have related to a participation gap, focusing not just on access but on the quality of interactions when digital tools are used (Dolan, 2016; Jenkins, 2009; Jocius, 2013). With HyFlex teaching, equity is often discussed in the capacity of achieving similar learning outcomes (Howell, 2022). Binnewies and Wang (2019) discussed the necessity that students should not be 'disadvantaged by choosing one mode over the other.' Issues of equity that should be taken into consideration during instructional design and implementation of HyFlex courses include choice of technology; support of students; student ability to use an equitable learning environment; and equal access to the instructor, including body language, direction of instructor attention, etc. (Binnewies & Wang, 2019; Lakhal et al., 2017). More recently, Mentzer et al. (2023) also studied the HyFlex model to ensure that students' basic psychological needs were being met equitably. They focused on the psychological needs of 'autonomy, competence, and relatedness' and found equitable results in a HyFlex group compared with those taking a traditional model of the course studied (Mentzer et al., 2023, p. 277). Students in HyFlex had lower levels of frustration, but also lower connection with their peers. This issue of equity was discussed in the present study from the beginning of syllabus design, in research meetings, and in the retrospective analysis when considering student outcome data.

Engagement in community

When discussing the needs of the doctoral programme, administrative leaders in the college expressed concern that in moving from a traditional to HyFlex doctoral programme, they wanted to ensure that students, whether participating online, face-to-face, or both, had the social interaction, with both their peers and instructors, necessary to build a scholarly community. From the previously discussed study by Mentzer et al. (2023), this is a valid concern as HyFlex students had statistically significantly less peer relatedness than their counterparts in traditional classrooms. However, their connection to their instructor was not statistically significant in this difference. One challenge to this engagement in the research literature on HyFlex is the physical space of the classroom (Boelens et al., 2017; Kohnke & Moorhouse, 2021; Leijon & Lundgren, 2019). Bell et al. (2014) found that these challenges included whether the space was large enough as well as whether there were the multiple spaces needed for the multiplicity in conferencing often being done in HyFlex classrooms. Overall, students in HyFlex classroom environments reported high social interaction with the instructor and with their like group (online or face-to-face) and enjoyed hearing increased perspectives brought by students attending courses from an increased variety of backgrounds and viewpoints. Yet, students also felt that the digital tools could potentially hinder communication and that online and face-to-face students needed increased engagement (Stewart et al., 2011). Thus,

engagement was discussed monthly by the research team, and feedback was sought from students on this element in their survey data.

Method

DBR rose out of a need for more methods of research with techniques capable of responding to the ecological contexts of classrooms rather than laboratories (Brown, 1992). Some elements that define this method are a focus on a pedagogical goal, design of an intervention, and modifications to that intervention as a response to evaluating progress towards that goal (Howell et al., 2021; Reinking & Bradley, 2008). DBR often uses mixed methods of data collection and analysis, an approach which was implemented in this study, and is inclusive of an interdisciplinary team of researchers, also included in this study, with a team of researchers each representing a different field in education (Brown, 1992; Collins, 1999). DBR often works according to a framework of six questions; the first and second are described in the preceding sections, and the remainder addressed in our results (Bradley & Reinking, 2011): (1) What is the pedagogical goal and how is it of value to education? (2) What is a justifiable intervention to achieve this goal? (3) What factors enhance or inhibit the intervention? (4) What modifications are needed based upon such factors? (5) Are there unanticipated outcomes of the intervention (those seemingly unrelated to the essential elements)? and (6) Has there been progress towards the goal?

Context

DBR often entails a team of researchers being participant-observers (DeWalt & DeWalt, 2002). In this team, two of the researchers taught the two doctoral courses being studied and met with a third researcher during research team meetings to discuss the progress of the intervention. The three-credit hour classes were each taught on a semester basis, meeting once per week for 3 h. The researcher met with each teacher-researcher monthly for both an observation of their respective courses and a debriefing following this observation. The participants were all doctoral students pursuing degrees in education. There were 37 students who gave informed consent to participate, and out of those who self-identified ($n = 36$) for their race and gender, there were 27 White females, 2 two White males, 6 six Black females, and 1 female identifying as Asian or Pacific Islander. Thus, 81% of these participants identifying race were White. According to the American Council of Education (2022) in 2015–16, the makeup of graduate students in the United States was 56% White, so our sample of students was slightly less diverse than the typical graduate classroom in the United States. Furthermore, participants in this study were mostly female, which is representative of the majority female graduate student body in the United States, although this majority is typically less pronounced at 59.3% in 2015–16. These students were equally split between pursuing their doctoral degree either full or part-time. The focus of one of the doctoral courses was writing academic literature reviews and studying theory, while the other was a research methods course. When referring to participants in the study, we use the pronoun *they* to use gender inclusive language.

The college hosting both courses broached shifting to a HyFlex model for doctoral programmes in 2019 due to reduced enrolments. Each of these doctoral programmes

started their first HyFlex cohort in the fall of 2021, offering students choices between online synchronous and face-to-face instruction. Asynchronous online elements were left to the respective instructors of courses as to whether to include them and, if so, to what degree.

Data sources and analysis

Data included student grades as well as a research log, observations, and surveys (see Table 1). The research team analysed this data to investigate inhibiting and enhancing factors of the intervention iteratively. All data were collected and analysed with appropriate institutional review board permissions. Then, as is typical in DBR, a holistic analysis of the data was conducted, typically called a retrospective analysis of the data (Gravemeijer & Cobb, 2006; Reinking & Bradley, 2008). In the retrospective analysis, we used Blair's (2015) guidelines on coding, which discussed that both a priori and emergent coding are accepted qualitative coding methods. However, a priori coding is particularly suited for determining how a research problem fits within the existent literature; thus, we proceeded with a priori coding to analyse how our data fit within these framework questions of DBR. The five codes will be presented in our results: Inhibiting and enhancing factors, modifications made, unanticipated outcomes, and progress towards the goal. The qualitative data from the open-ended survey questions, observations, and research log were coded according to these codes and then compared with the quantitative answers on the survey and grades as a point of triangulation of data. The surveys, both pre and post, were designed to include constructs related to the essential elements with quantitative Likert-scale, multiple choice and qualitative, open-ended responses.

We used concurrent analysis, where quantitative and qualitative were analysed separately and then considered respective of one another to corroborate findings (Creswell & Clark, 2017). Two questions were analysed on the survey responses for their pre- and post-survey change. The statistical analysis of the interaction and knowledge questions proceeded in two steps. The first step involved statistical graphics to visualise individual student pre-post changes in the question answers, and the overall mean pre-post changes. The second step was a paired t-test (with individual students defining a pair of answers) to determine if the overall question means showed a statistically significant change from pre to post.

Finally, in our discussion (see Table 2), we bring together the qualitative and quantitative findings as they relate to each essential element of the intervention. To assess the influence of each element, we analysed each according to three quality factors typical of

Table 1. Data collection.

Data	Description	Frequency
Student grades	The letter grade of the course assigned by each respective instructor.	End of course
Research log	A journal of each research activity maintained by the first author.	Recorded research meetings and reflections
Observations	The first author observed each instructor's course, including both face-to-face and online instruction. After each observation, the first author debriefed with each instructor.	Monthly
Surveys	A pre- and post-survey including both qualitative and quantitative responses for students participating in courses.	At the beginning and end of each course

Table 2. Analysis of essential elements.

Supporting finding	Essential element	Quality measures: efficiency, appeal, and effectiveness	Implications
Inhibiting Factor; Modifications Made (Infrastructure)	Digital, Multimodal Tools	Efficiency, Appeal, and Effectiveness	HyFlex is not without cost needed for technological infrastructure.
Enhancing Factor; Modifications Made (Instruction); Progress Toward the Goal	Equity Of Online and Face-To-Face Learning Environments	Effectiveness and Appeal	Equitable learning outcomes in HyFlex doctoral courses indicate the potential of serving students previously underserved in higher education.
Inhibiting Factor; Unanticipated Outcomes	Engagement in Community	Efficiency, Appeal, and Effectiveness	Engagement remains an area to address when using HyFlex in higher education.

DBR: efficiency, appeal, and effectiveness (Howell et al., 2021; Reigeluth & Frick, 1999). Effectiveness relates to how well the intervention worked; efficiency relates to the costs associated with this effectiveness; and appeal conveys a study of the costs versus the benefits. Reigeluth and Frick (1999) suggested that evaluation based on these criteria helps to generalise knowledge for the design of future research.

Results

We discuss our findings in terms of the questions remaining of the DBR framework (Bradley & Reinking, 2011): What factors enhanced or inhibited the intervention? What modifications were needed based upon such factors? Were there unanticipated outcomes of the intervention (those seemingly unrelated to the essential elements)? Was there progress towards the goal?

Inhibiting and enhancing factors

The major inhibiting factor was the classroom design and infrastructure given that there were frequent challenges with the classroom visual and sound systems not being able to ensure equitable participation for both online and in-class students, as noted in the classroom observations, research log, and survey responses. This technology glitch was frustrating for both the professors and the students. Noted in the observations, the instructor often had to have students come to speak directly into the computer as sound would not pick up from various parts of the classroom. In addition, the students replied on their survey that 'The technology doesn't work – we can't see our classmates and engage with them.' This lack of technological success was also triangulated by the survey data in which students noted that the digital tools mainly equalled (rather than exceeded or fell short of) their expectations (57%). Students had limited expectations and experiences with technology here, merely expressing as one student noted, 'Everything worked.'

Another inhibiting factor was social interaction, triangulated in observation and survey data. In the observation data, it was noted that many students did not attend face-to-face sessions. Thus, for one class session, a student who had come to class to participate and was enthusiastic about such attendance had to put in their ear buds and participate in the breakout rooms virtually. In the pre-survey data, the majority of students, 56%, said that

they wanted social interaction with colleagues 2–3 times a week. However, in the post-survey, the largest percentage of student responses (48%) reported that this interaction only occurred once per week. The statistical graphic results for the interaction question suggested that an almost equal number of students increased, decreased, and stayed the same in terms of their answer to the interaction question. The paired t-test indicated no statistically significant difference in the means (p-value >0.05). Thus, this seemed like an area requiring attention but did not appear to have a statistically significant impact.

Enhancing factors included the flexibility in the design, allowing both the instructor and students to tailor learning to meet individual student needs, as noted in the observations, research log, and survey data such as 86% of responses noting their current content knowledge of the course as good or excellent. Some examples of this tailoring were included in each of the courses. In the methods course, survey data showed that flipped content in the course, where the instructor presented lectures via videos in the course modules and used the course time for discussion and reflection, worked well for the students, so they continued this format. Further, responding to a vacuum of student response online, presumably as they were unsure of when to speak, the instructor made a point of calling on students by name. With the literature review course, the teacher included multiple points of interaction, synchronously and asynchronously. For instance, with the synchronous time, they arranged a guest speaker, and in asynchronous time students were able to schedule personal meetings with the instructor. These one-to-one meetings with the instructor were considered asynchronous in that they were outside the whole class required instructional time and were organised according to the student's schedule (Hwang & Wang, 2004). The students noted this flexibility in their survey responses as well. For example, one student wrote, 'The flexibility in time was built into our course in a way that didn't waste any time and gave me what I needed to do deep research.' Another student echoed the importance of this flexibility: 'The professor was flexible in choice of modality based on the lesson and individual circumstance.'

Modifications made

We noted two different types of modifications needed, those related to instruction and infrastructure. While instructional adaptations were made that seemed positive, such as capitalising on students' expressed preference for flipped content delivery and conferencing, necessary infrastructure changes could not be addressed due to their systematic and costly nature. Regarding the instructional changes, the flexibility of HyFlex was appreciated, especially as in the first 3 weeks of one of the courses, the classes were online due to an influx of COVID cases. Further, that flexibility also allowed changes due to inhibiting factors, such as increased class size. One instructor discussed how the format allowed them to arrange for asynchronous meetings that ensured that they could still give individual attention to the writing needs of the doctoral students despite their concern with broadening class sizes. Sometimes the students also brought helpful modifications such as during their asynchronous meetings: where some students were meeting with the instructor, other students formed 'accountability groups' to meet in small groups online to do their writing, and this was coordinated by the instructor.

The instructor of the methods course had a constant concern with the equality of the work seen in full-time and part-time students. While they were able to adjust for

group work and the length of time needed for quizzes, for instance, there remained a predicament that the part-time students, who were largely attending online, did not have access to some of the opportunities of the face-to-face students, such as access to a lab and real data to analyse versus created data scenarios. This is problematic as one face-to-face, full-time student in this course described this experience as fundamental to their learning and their favourite component of the course. This remained a need to be addressed. Further, some instructional adaptations were able to be made such as creating breakout rooms in Zoom to encourage small group interaction, although there were technological limitations to this arrangement such as Zoom only being designed to allow for one prearranged group formatting rather than multiple iterations of groups. Further, face-to-face students often needed multiple physical classrooms so that the central classroom could be used for the instructor to talk with the online groups and the in-class students could interact with the online students, and this remained an issue to resolve perhaps with scheduling courses in future terms.

Most of the modifications left unimplemented were those requiring larger infrastructure support. This included the need for multiple physical spaces or those with more sound barriers as well as a need for a classroom outfitted with speakers and cameras capable of pivoting to those speaking. These needs were taken to others at the university applying for internal grants; however, one challenge met was that these grant opportunities for outfitting classrooms were typically only available for undergraduates. We also sought ideas from other institutions and found that some have addressed this need with external grants such as the USDA Distance Learning and Telemedicine Grant, see Rider and Moore (2021).

Unanticipated outcomes

Eighty-two per cent of post-survey responses reflected students taking the course online synchronously, raising a question as to whether the option of in-class participation was worth the cost and effort. This was a jump from the 76% who said that they would be taking the course online synchronously in the pre-survey. These students seemed happy with their chosen modality as 95% responded 'probably yes' or 'definitely yes' when asked if the course met their expectations for their chosen modality. However, the qualitative data indicated that there was some nuance to this online synchronous choice, as the pre-survey noted some students wanting more choices for attending online asynchronously as well as synchronously. The modality did not seem to hurt either student attendance or grades as all students passed the course and reported average to above average attendance in comparison with other courses. Yet, those students who did participate face-to-face in class seemed to be enthusiasts for this mode due to their dedication to the programme (full-time students, in particular) or their learning needs, according to our observation data and research log. For instance, one student commented in their survey response: 'It was frustrating being an in-person student and forced to become an online student due to lack of other in person students.' Thus, these options of online synchronous and asynchronous as well as face-to-face attendance seemed to be a high priority for students in the programme, despite attendance not always reflecting this priority.

Progress toward the goal

Student grades indicate that they had an equitable experience succeeding in HyFlex courses as all students received credit for their course, with 100% of students completing the course. Further, this success is triangulated with the survey data as 97% of participants indicated that the course met their goals. In addition, regarding their disciplinary knowledge in the respective courses, the majority of responses on the pre-survey (72%) rated their content knowledge as average. Yet, on the post-survey, the majority of students (80%) rated their content knowledge as good. The statistical graphic results for the knowledge question suggested that a majority of students increased in terms of their answer to the knowledge question, resulting in an increase in the post mean over the pre mean. The paired t-test indicated that the increase was statistically significant (p-value <0.05). Thus, this seems to provide evidence towards the goal of leveraging HyFlex for an equitable doctoral education in that students are succeeding academically. The second part of this goal is that this education would also be accessible. The students were given options of attending online synchronously or face-to-face, but as previously discussed, there were at times issues with those wanting to be present face-to-face not attending and with students wanting more interaction in this access. Catering to these students' education was also harder on their instructors as one instructor noted at times having to provide more instructional support than in a typical doctoral class: 'Done a lot of individual support, 30 emails a week, and meetings.' However, for the students, when asked if the HyFlex courses met their goals, they overwhelmingly responded that these needs were met. The following representative examples show this affirmation:

> 'Extremely informative.'
> 'Due to current position, I have been able to implement knowledge within the classroom and share with peers.'
> 'It provided the methods needed to conduct the type of research discussed.'

Thus, due to the statistically significant gain in content knowledge and the qualitative satisfaction that the course met their goals, these courses seem to have made progress, especially for students receiving equitable learning, though they would appreciate even more flexibility in access. However, for the instructors, this teaching required more of them than they may have expected, and this was not overcome during teaching one HyFlex class. For example, the methods instructor stated that they really enjoyed the course and thought HyFlex would be fine in the long run, but regarding the collaboration between the two groups (online and face-to-face), I 'feel like I'm teaching two separate groups.'

Discussion

How does DBR answer the following question: Was the intervention successful? To address this question, researchers go beyond a simple yes or no, or in other methods ask whether there was statistical significance or not. Instead, DBR looks at elements of efficiency, appeal, and effectiveness for each of the essential elements of the intervention (Howell et al., 2021; Reigeluth & Frick, 1999). Thus, we review here each of our essential elements and their implications for students, teachers, and researchers regarding the

HyFlex model. In Table 2 we demonstrate the basis for this determination based upon collapsed findings previously discussed.

While the digital, multimodal tools of this intervention were effective in that they were essential to the flexibility of the HyFlex courses, hosted on Canvas and using Zoom for videoconferencing, they were also an inhibiting factor that decreased the efficiency and appeal of the intervention for both the students and the instructors. The main inhibiting factor here that could not be overcome, at least in this first iteration of the study, was the need for modifications to infrastructure. Face-to-face students grew frustrated with repeating themselves, and online students were prevented from connecting with their face-to-face colleagues due to the lack of sound geared to individual students in the physical classroom spaces. The instructors also had to ask students to repeat themselves or to present from certain points in the classroom, making the class more repetitive and cumbersome than was designed. This is a modification that will require large investment in the future, potentially calling for external grant funding, as typical infrastructure improvements are geared towards undergraduates at the college of the study. Thus, while the literature on HyFlex often speaks to the successes of this mode for its consolidation of costs (Howell, 2022; Lakhal et al., 2017; Wang et al., 2017), there is an initial investment in infrastructure that cannot be ignored.

Regarding the equity of online and face-to-face learning environments, two findings suggest that this may be an equitable platform for students to excel in higher education, indicating the effectiveness and appeal of this element of the intervention, at least for students. Multiple data points indicated equitable success for student learning in the course. Students all completed the course with passing grades, and the majority said that the course met their learning goals. Further, they indicated a statistically significant growth in content knowledge. This progress suggests that the students had equitable learning that contributed to their success, indicating both the effectiveness and appeal of this essential element. This learning growth builds upon the existent literature stating that HyFlex was not detrimental to learning outcomes, and could, in fact, positively influence them (Binnewies & Wang, 2019; Calafiore & Giudici, 2021; Miller et al., 2013). This is especially important as this success was represented by participants of whom 19% were students of colour, an underrepresented group in doctoral degrees in higher education and overrepresented in online programmes (National Science Foundation, 2019). Further, these underrepresented students disproportionately crowd into open-access institutions, whereas their White peers access more selective, highly regarded research institutions (Sublett, 2020). Thus, HyFlex may be a mode capable of redressing this imbalance. In addition, the instructional modifications that were able to be made seemed to contribute to an equitable learning environment as discussed, in that the instructor could tailor the course to meet student needs, and the students could also make modifications, such as meeting in small groups during asynchronous learning days mentioned previously. This seemed to appeal to students and may also have contributed to their learning success.

Finally, engagement in community was an area that may need further support to contribute to the potential appeal, effectiveness, and efficiency of the intervention. Interaction, not meeting student expectations discussed in the inhibiting factors from pre- to post-survey, while not statistically significant, shows that the students may desire more interaction with their colleagues for the appeal and effectiveness of their learning. Furthermore, the efficiency of the intervention was inhibited due to the lack of face-to-

face attendance as described in the unexpected outcomes. While face-to-face interaction was significant to those selecting this mode and thus should not be eliminated, future iterations must continue to work towards making the integration of such interaction as seamless as in a completely online or face-to-face course. This engagement was frustrating for the students as well as the instructors, as we noted in our observations at the end of the semester that an instructor felt that though they did not mind teaching this way, they would prefer face-to-face, and they wanted to ensure the technology met the student needs, which was not completely apparent. Interaction between online and face-to-face groups is important, especially related to HyFlex addressing racial barriers of access to higher education. For instance, all of the students who identified taking the courses in some face-to-face component were students who identified as White. Yet, all students who identified as students of colour took the courses online synchronously. Thus, interaction across groups is needed to ensure that racial barriers are not enforced rather than overcome.

Limitations and future work

Reigeluth and Frick (1999, p. 635) suggest that DBR is not a single endeavour but rather 'a matter of successive approximation … refined over many iterations.' Thus, this study discusses one iteration with a relatively small sample size of a multiple phase DBR study. This first phase studied two courses and made micro modifications before making macro changes in the second phase, with two additional courses studied in a subsequent semester. Both replication in similar contexts, such as the second phase of this study, and studying the intervention with varied environments and participants, needed in further research, contribute to the *situationality* of DBR research (Reigeluth & Frick, 1999). Situationality then contributes to generalisability as researchers can determine how findings apply across such contexts. These iterations will need to continue with the HyFlex model across varied situations to contribute to generalisability. While this study addresses a gap in research by studying HyFlex implemented at the doctoral level, this is also a limitation of this study. Future research will need to test other samples across higher education or other fields being studied, including undergraduates, such as the work begun by Mentzer et al. (2023). Further, while this study focused upon initial implementation of the HyFlex model, future research should address the pedagogy needed specific to HyFlex instruction (Howell et al., 2023).

Conclusion

Overall, when we consider the success of this intervention towards the goal of leveraging the HyFlex model of education across courses towards more accessible, equitable education in doctoral programmes, the results are somewhat dichotomous. The students seem to have achieved some success with learning gains that are equitable, yet there remains improvement in accessing the social interaction they are looking for. Yet, the instructors seemed less assured of this mode after teaching initial courses. They had larger class loads, more accommodation and differentiation, yet were given classrooms not yet equipped to handle such transition. It is perhaps not surprising then, that they had lingering hesitation of whether they met their students' needs in an equitable fashion. Thus, there remain modifications for future iterations: professional development tailored to designing HyFlex courses as noted by researchers such

as Abdelmalak and Parra (2016), Bell et al. (2014), and Raes et al. (2020), technological infrastructure needs, as well as ways to better encourage social interaction in the courses, such as seeking multiple physical spaces, affirming research such as Bell et al. (2014). This professional development will need to address not just pedagogical strategies specific to HyFlex (see Howell et al., 2023), but how instructors meet the changing physical demands of classrooms such as increased student numbers and student interaction and experiences across physical and digital contexts. However, this study contributes to the literature by going beyond anecdotal observations and systematically studying classroom implementation in several applications as recommended by multiple researchers (Abdelmalak & Parra, 2016; Binnewies & Wang, 2019; Howell et al., 2017; McGee, 2014; Miller et al., 2013). Furthermore, the method of this study, DBR, extends a 'what works mentality' and gives needed perspective, detailing not just the *what* but the *how* and *when*, in the ecological context of higher education. Methodologies such as these, going beyond whether interventions do or do not work, are particularly needed in those rapidly taking up technology to discuss not just successes, but also failure, reflection, and the design in development (Gaydos, 2015). Higher education has been forced to evolve in a rapidly advancing and changing era of education, especially due to the COVID-19 pandemic. We hope this study gives needed reflection on both the potential and challenges of the HyFlex model.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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