The Converged Learning Model: Melding the Physical and Virtual Environments for Teaching and Learning Before, During, and After the Pandemic

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We share, through this case study, how our converged learning model formed the basis for NJIT's Pandemic Recovery Plan and describe how our mission while ensuring the safety and well-being of our campus community, endured. Having proven successful on a small scale, the converged learning model was expanded, by necessity, to most freshman and sophomore level classes in Fall 2020, with junior, senior, and graduate level courses added in Spring 2021. Through this modality, the social distance could be maintained by inviting only some of the students to physically attend each class session while others joined remotely, alternating invitations to allow all students the opportunity to attend class in person, and enabling our university to remain open essentially throughout the pandemic. Surveys captured student and faculty perceptions of the technology and the mode of learning and informed adjustments, and course evaluations assessed students' perceptions of learning in the modality. Results suggest that the rapid expansion of converged learning initially challenged both students and faculty, but by the second semester, because of strategic planning and investments, every measured outcome showed improvement.

Keywords: converged learning, pedagogy and technology, learning outcomes

ABOUT THE UNIVERSITY

New Jersey Institute of Technology (NJIT) is the public polytechnic research university of the state of New Jersey. Founded in 1881 as the Newark Technical School, NJIT is now classified as a Carnegie Doctoral Very High Research (R1) university comprising six academic colleges. The College of Science and Liberal Arts (CSLA), the Hillier College of Architecture and Design (HCAD), the Martin Tuchman School of Management (MTSM), the Newark College of Engineering (NCE), and the Ying Wu College of Computing (YWCC) award undergraduate, master's, and doctoral degrees as well as post-baccalaureate certificates. The Albert Dorman Honors College offers a more enriching experience for undergraduate students majoring in any of the university's academic disciplines.

A LONG HISTORY OF TECHNOLOGY-ENABLED TEACHING AND LEARNING

NJIT has a long and rich history in online education, an outgrowth of funded research and development activities deploying digital tools in support of all modes of instruction and in all disciplines (Deek, Deek, & Friedman, 1999). In 1975, the Electronic Information Exchange System (EIES), a tool for group communications, was developed with university support as well as a grant from the National Science Foundation. EIES features included threaded discussion space, e-mail, shared and private notebook and scratchpad space, instant messaging, both public and private conferences, voting, user directory, message receipt confirmation, and a grade book. These innovations are credited as being predecessors to many of today's synchronous and asynchronous commercial groupware systems (Hiltz & Turoff, 2005). In 1978, professors Roxanne Hiltz and Murray Turoff, leaders of NJIT's Computerized Conferencing and Communications Center, published *The Network Nation—Human Communication Via Computer*, and in the 1980s NJIT earned a reputation as a visionary leader in online education for its pioneering work on the virtual classroom and asynchronous learning (Hiltz, 1986). NJIT coined and trademarked the term Virtual Classroom® in 1984 and began to offer fully online courses, utilizing the EIES system with lectures delivered by videotape and cable TV, in the mid-1980s. This "classroom without walls" concept was created with funding from the Annenberg/CPB Project.

Building on the Annenberg/CPB Project, from 1993 to 1996, the Alfred P. Sloan Foundation funded "Video Plus Virtual Classroom: Educational Excellence Through Self-Paced Learning." This project yielded a complete/accelerated undergraduate degree in Information Systems. A subsequent Sloan Foundation grant (1997-1999) funded "New Project: From Virtual Classroom to Virtual University: Institutionalizing Asynchronous Learning Networks at NJIT." This project sought to add graduate certificates to the existing undergraduate degree, also through ALN. In 2000, the New Jersey Commission on Higher Education funded "New Jersey Information-Technology Opportunities for the Workforce, Education, and Research" (NJ I-TOWER). Funds from this initiative provided support for the conversion of a large number of courses to an online format as well as corresponding faculty development workshops. This also facilitated the purchase of the necessary software and hardware such as presentation and animation applications, sophisticated projectors, microphones, scanners, printers, and digital cameras.

CONVERGED LEARNING

In 2013, NJIT proposed an integrated digital learning model to achieve a functional melding of the physical and virtual campus in a learning environment in which students have the opportunity to engage in a course either from a distance or in a classroom environment, by choice and alternating the mode to fit their needs, with technology blurring the distinction between the two environments.

Thus, academic leadership at NJIT proposed a new concept of *Convergence–A Vision and Framework for Leadership in Digital Learning* (Office of the Provost, 2013). This educational vision outlined a new modality in which "the physical classroom and the virtual classroom will asymptotically converge." Through specialized technology, remote learners and those physically present in the classroom would participate in the same course section in real-time regardless of location, thereby creating a "converged learning" environment.

The objective of this new model was to create an *anywhere* classroom in which a student would have the opportunity to transparently engage in learning regardless of location, with both modalities occurring in the same course section. Because of individual circumstances, one mode might have advantages for a given student at a given time, but the tools and venues open to all students would provide equivalent outcomes, thereby ensuring equity and access. This synergy also extended to university resources. Because converged learning students could, for each class session, choose to attend by coming to the classroom, logging into the class from their dorms or nearby apartments, or joining the class from another state or country, admission, registration procedures, and costs would be the same. Students participating in converged learning would have access to all campus and university resources and would be treated the same as traditional (face-to-face) students.

In addition, academic standards would be consistent because course content and learning outcomes would stand independent of delivery mode. Those attending class in person would experience the delivery of the course content as they would in a traditional class—except that they would be joined via synchronous streaming by other students taking the course from a distance, anywhere in the world. These remote students would be held to the same standards for academic excellence as their classmates on campus: they would engage in the same discussions, do the same homework, and take the same exams. In this way, the classroom would be brought to the remote learner in real-time, and he or she would participate in the class in the same way as those physically present.

The converged learning initiative was integrated into NJIT's *2020 Vision* strategic plan (Office of the Provost, 2015) which established an ambitious set of strategic goals and objectives for the university to achieve by 2020. For converged learning, the objective was to provide a more inclusive learning environment that would allow students to attend class regardless of their location or situation while at the same time reclaiming NJIT's leadership in digital learning that it held more than a quarter century before. To this end, the converged modality was launched in Spring of 2016 for a small number of courses in specially equipped classrooms. The significant cost of investment in instructional technology required for the converged learning model was a factor in instituting a steady but cautious approach to adoption and expansion. As a result, a comprehensive assessment of the learning model and its outcomes was not initially feasible, although converged courses were included in all routine assessments of learning outcomes conducted at the university. Recent circumstances have changed both of these situations.

In Spring 2020, like the rest of the higher education enterprise and the rest of the world for that matter, the global pandemic forced NJIT to move to remote operations, including instruction, research, and business functions. Our deliberate investments in instructional technology and increased digital capabilities across our campus, accelerated in the period immediately after the start of the pandemic, proved both wise and timely. In March 2020, NJIT instantaneously and seamlessly shifted to converged learning in which instructors taught synchronously using their home computers with students joining regardless of location. This remote converged format worked remarkably well given its sudden implementation. With a minimum of equipment (laptop, microphone, and camera), instructors were teaching and interacting with their students ten days after the official move to remote operations. For instructors and students lacking the necessary technologies, the university provided devices to facilitate the sudden transition to remote converged learning.

At the same time, guided by a comprehensive *Pandemic Recovery Plan* (Office of the Provost, 2020), the university began to prepare for a return to campus by the Fall of that year, using converged learning as a means to support appropriate social distancing while still providing students with on-campus, face-to-face experiences. The converged format provided flexibility that was well suited to the uncertainty caused by the pandemic. First, it allowed students to determine their preferred method of attendance: for those students anxious to return to (or come to) campus, converged learning provided the option to attend class in person or join from the library, residence halls, or other study spaces made available by the university; for students (or families) concerned about returning too soon, remote attendance was available but with the ever-present option to choose to attend in person.

THE INFRASTRUCTURE

The expansion of the converged learning model required a substantial investment in technology as well as the training of faculty. In January 2020, NJIT had 11 classrooms equipped with built-in sophisticated video conferencing systems to facilitate converged teaching and learning. By the fall of that year, 17 additional classrooms (spread throughout six buildings on campus) had been equipped with built-in systems. An additional 109 mobile carts with unified intelligent 360° camera/microphone/speaker video conferencing technology were purchased and distributed across academic spaces.

At the same time, the university's instructional designers worked with faculty to adapt their courses to the converged modality, and a classroom with a built-in video conferencing system was made available for

faculty to become acquainted with the technology before the start of the semester. Members of the Office of Digital Learning were on call to troubleshoot problems.

The converged learning modality allowed shifts to the appropriate degree of social distancing by setting a maximum number of face-to-face students allowed in each class. Students were split into groups that alternated in-class attendance so that there were never more than 33% or 50% of enrolled students in a classroom at the same time. To manage classroom attendance, an app with AI capabilities was implemented before the start of the Fall 2020 semester. This app offered classroom seats to a subset of enrolled students on a rotating basis, essentially providing students who wished to converge physically a chance to be in the classroom within a certain time cycle. Students who accepted the invitation to attend class in person that day were guaranteed a seat that was appropriately distanced from other students in attendance. If a student declined the invitation to attend in person, that seat was offered to another student, with preference given to students who had not physically attended a class recently.

THE CHALLENGES

The rapid expansion of converged learning raised concerns about the quality of teaching and learning in this modality. To address these concerns, and seize the opportunity to finally conduct a wide-scale assessment of the model, surveys were distributed in the Fall and Spring semesters to assess student and faculty satisfaction with the converged learning and teaching experience and to identify any issues requiring immediate attention. One issue that was identified was the difficulty for remote students in hearing the instructors in classrooms equipped with mobile carts, with only 44% of students rating the quality of the audio as excellent or good. To address this problem, clip-on microphones were provided to faculty, resulting in a 17% increase in excellent and good ratings (61%) of audio by the spring of 2021. Additional technologies were also provided, including document cameras in courses where faculty demonstrated how to solve complex equations.

Interactions between students were also found to be a challenge in the Fall 2020, with only 27% of students stating that opportunities to interact with classmates were excellent or good. Additional faculty training for the converged modality, as well as modifications to video conferencing technologies such as breakout rooms, led to more positive perceptions regarding opportunities for interaction by the spring of 2021, with 32% of students rating the opportunities as excellent or good. Similarly, in Fall of 2020, 29% of students rated their ability to stay connected with classmates as excellent or good, increasing to 36% in Spring 2021.

Training, technological support, and the experiences of the fall semester all served to substantially improve the student learning experience for Spring 2021. The support provided by the Office of Digital Learning and the university's instructional designers resulted in a 16% increase in students' perceptions regarding their instructors' mastery of the course delivery software, with 42% of students rating this as good or excellent in Fall 2020 compared to 58% in Spring 2021. Students also felt more confident in their skills with remote learning technology, with excellent and above-average ratings increasing from 56% (Fall 2020) to 63% (Spring 2021).

Overall, the converged learning model had some compelling benefits. Particularly during the pandemic, students wishing to have on-campus interactions were still able to do so, while students concerned about coming to campus were able to continue their education by joining converged courses virtually. The converged model also facilitated the development of contingency plans should any change (increase or decrease) in social distancing be mandated. For example, if the semester began fully remote, the easing of restrictions could be accommodated seamlessly by increasing in-person presence through the converged modality.

METHODOLOGY

Initial assessments of the converged modality were limited by the small number of classrooms equipped to offer courses in that modality. With the rapid expansion of the converged learning format, course

evaluations were used to conduct a large-scale assessment of learning in the converged format as well as a comparison to other teaching and learning modalities including fully online (completely asynchronous instruction) and synchronous online instruction.

RESULTS

In the Fall of 2020, a total of 42% of all academic courses were offered in the converged modality, with priority given to freshmen and sophomore-level classes to ensure these students built a connection to the NJIT community through face-to-face experiences. Labs were also offered in the converged modality with students alternating in-person attendance to gain the practical experience necessary for lab work. In Spring 2021, 34% of courses were offered in the converged modality, including upper-level undergraduate classes and graduate-level classes. A breakdown of course delivery modes by the college is shown in Table 1.

TABLE 1
COURSE FREQUENCY DISTRIBUTION BY DELIVERY MODES ACROSS COLLEGES

		2020 Fall		2021 Spring	
		Total=1826		Total=1683	
		n	%	n	%
HCAD	Converged Learning	34	37.0	33	35.5
	Online	5	5.4	5	5.4
	Synch Online	53	57.6	55	59.1
YWCC	Converged Learning	92	26.3	81	23.9
	Online	57	16.3	51	15.0
	Synch Online	201	57.4	207	61.1
NCE	Converged Learning	169	33.3	207	41.6
	Online	48	9.5	45	9.1
	Synch Online	290	57.2	245	49.3
CSLA	Converged Learning	426	61.4	220	35.7
	F2F	2	0.3	-	0.0
	Online	59	8.5	61	9.9
	Synch Online	207	29.8	35	54.4
MTSM	Converged Learning	40	32.3	33	27.0
	Online	32	25.8	37	30.3
	Synch Online	52	41.9	52	42.6

Note 1. This table presents descriptive information at the course level.
2. Courses that opted out or have no responses in Course Evaluation are not included.
3. Percentages may not add up to 100 due to rounding.

A robust set of course sections were offered by all NJIT colleges and schools in the converged modality, with significant participation by the College of Science and Liberal Arts. This is attributed to their dual role at the university in that they offer their degree programs but are also responsible for a large component of the lower-level undergraduate general education requirements (GER) including courses in mathematics, physics, chemistry, social sciences, and first-year writing. As early as the second semester of their first year, students in many of our disciplines also begin to take courses in their major, leading to a more balanced distribution of converged courses between all the schools and colleges by the Spring 2021 semester.

STUDENT PERCEPTIONS OF COURSES IN VARIOUS DELIVERY MODES

Following the standard practice at the university, at the end of the Fall 2020 and Spring 2021 semesters, students in all courses were invited to submit course evaluations assessing areas such as instruction, course materials, and the educational value of the course. The results of these evaluations were compared for courses offered in the converged modality (CL) and courses offered in the synchronous online (SYN) modality because both formats offered synchronous instruction. As can be seen in Table 2 below, during the fall semester, students typically reported better perceptions of their experiences in the synchronous online courses, but by the spring semester, perceptions of converged learning had improved and often surpassed synchronous online.

TABLE 2
STUDENTS' PERCEPTIONS OF THEIR LEARNING EXPERIENCES

	2020 Fall			2021 Spring		
School	CL	SYN	Sig.	CL	SYN	Sig.
The quality of the course materials.						
HCAD	3.02	3.13	*	3.37	3.19	**
YWCC	2.61	3.17	***	3.05	3.04	NS
NCE	3.02	3.05	NS	3.05	3.08	NS
CSLA	2.93	3.17	***	3.17	3.10	**
MTSM	3.02	3.17	**	3.32	2.99	***
The overall educational value of the course.						
HCAD	3.05	3.15	NS	3.41	3.20	**
YWCC	2.63	3.22	***	3.07	3.06	NS
NCE	3.05	3.09	NS	3.11	3.11	NS
CSLA	2.87	3.13	***	3.09	3.05	NS
MTSM	3.00	3.18	***	3.32	2.99	***

Instructor's ability to communicate the course content.						
HCAD	3.05	3.16	NS	3.52	3.23	***
YWCC	2.62	3.29	***	3.12	3.18	NS
NCE	3.08	3.13	NS	3.13	3.15	NS
CSLA	3.04	3.36	***	3.26	3.33	**
MTSM	3.11	3.22	*	3.52	3.15	***
Instructor's encouragement of active class participation.						
HCAD	3.13	3.17	NS	3.47	3.26	***
YWCC	2.57	3.23	***	3.11	3.12	NS
NCE	3.02	3.13	***	3.11	3.12	NS
CSLA	3.04	3.34	***	3.24	3.29	*
MTSM	3.03	3.23	***	3.41	3.06	***
Instructor's promptness and full use of class time.						
HCAD	3.32	3.30	NS	3.57	3.35	***
YWCC	3.02	3.39	***	3.35	3.33	NS
NCE	3.24	3.31	**	3.27	3.31	NS
CSLA	3.29	3.52	***	3.42	3.47	**
MTSM	3.25	3.33	NS	3.53	3.26	***
Overall teaching effectiveness of the instructor.						
HCAD	3.01	3.11	NS	3.48	3.15	***
YWCC	2.58	3.23	***	3.07	3.11	NS
NCE	3.03	3.06	NS	3.05	3.09	NS
CSLA	2.99	3.29	***	3.24	3.26	NS
MTSM	3.06	3.20	*	3.45	3.08	***

Scale: 0 = Poor, 1 = Fair, 2 = Satisfactory, 3 = Good, 4 = Excellent
Note: This table presents student-level responses from the course evaluation survey.

These results suggest that the rapid expansion of the converged learning modality was challenging for both students and instructors. In the Fall 2020 course evaluations, all statistically significant differences suggested lower evaluations of converged learning courses than synchronous online courses. However, by

Spring 2021, a dramatic shift is evident, with statistically significant differences showing higher means for converged learning in almost all colleges. This suggests that both students and instructors had improved experiences once they had adjusted to this new learning format. However, improvements were not consistent across all colleges and schools; the smaller (not statistically significant) increases in NCE could be attributed to the difficulty, compared to other subjects, of conveying engineering content remotely and digitally. Additionally, in the past, many more courses in computing, humanities, and management had typically been offered in the converged modality. Because of this, NCE faculty had less experience teaching in this delivery mode. The engineering labs were the most difficult courses to deliver in the converged mode during the first semester. To address this, academic departments were very proactive in producing video content of laboratory experiments that were made available to students who chose to attend virtually or where space constraints limited the number of students who could attend physically. Interviews with students suggest that many other students also opted to use the videos to reinforce what they learned regardless of the modality. By the Spring 2021 semester, lab instruction and virtual student participation improved as the university had adequate time to identify software simulations to replace our rudimentary videos.

One major concern for faculty was the challenge of actively engaging students whose lives, like everyone else's, were abruptly disrupted in so many ways. However, an encouraging observation is that, in converged learning courses, some of the largest gains made between the fall and spring semesters were in the measure of the instructor's encouragement of active class participation. Having identified this as a concern in the Fall semester, instructors were able to significantly increase students' perceptions of engagement through a deliberate and conscious effort.

The instructor's ability to communicate the course content in the converged modality also increased between Fall 2020 and Spring 2021, resulting in a corresponding increase in students' perception of the overall educational value of the course. In fact, of all the measures listed, the educational value of the course experienced the most substantial gain in the converged learning format across all colleges.

PRACTICAL IMPLICATIONS

The rapid expansion of NJIT's converged learning format initially led to some "growing pains" as instructors and students adjusted to a blended classroom in which they could interact with the person sitting next to them or located hundreds of miles away. These challenges are reflected in the Fall 2020 course evaluation results. Yet the increases in satisfaction with the converged learning experience and the end-of-semester course evaluations by Spring 2021 suggest that once instructors and students acclimated to the new modality and worked through the technological issues, converged learning was a successful method for delivering a quality educational experience. In other words, despite the challenges, this experience proved that converged learning is a flexible and inclusive modality that allows learners to determine their preferred method of attending class on any given day while still sharing a common educational experience. Moreover, NJIT now has a proven approach to continue instructional delivery to our students even when physical disruptions occur.

Our large-scale implementation of the converged learning model also evidenced the necessity for all students and instructors to have access to the Internet as well as a suite of reliable computing and communication tools (UNESCO, 2020). As a polytechnic university, NJIT was able to quickly meet the needs of students and faculty. However, technology by itself has never been and will never be the sole enabler of learning. In other words, providing video conferencing technology is not equal to teaching. NJIT has recently created the Office of Online Programs which now oversees the expansion of our Digital Learning and Instructional Design efforts. The goal is to continue to work with academic departments to examine and enhance pedagogy related to delivering remote instruction digitally, emphasizing the content and its quality.

Another focus is to strengthen the connections between the different communities of students (traditional, remote, and mixed modal) and between these students and their instructors. A technology-rich learning environment will facilitate opportunities to interact through the application of emerging tools and

devices, and analytics will provide feedback on student engagement and interactions. Analytics and artificial intelligence will be used to personalize the learning experiences of individuals to suit their abilities and needs while also giving instructors a better understanding of students' learning styles. The STEM nature of our disciplines will also benefit from the adoption of augmented reality by bringing abstractions closer to reality, especially for lab-based courses.

FUTURE WORK

NJIT's transformational strategic plan, *2020 Vision*, resulted in significant improvements in student outcomes, tremendous growth in externally funded research, and substantial investments in classroom infrastructure. The university recently launched another ambitious plan, *Building on a Strong Foundation–NJIT 2025*. This plan, now in its third year, focuses on five different priorities: Students, Faculty, Research, Resources, and Prominence. An objective that crosscuts all of these priorities is the development of a virtual, global campus that will offer undergraduate and graduate programs using innovative remote delivery modalities as well as through the development of physical presences beyond our Newark campus. With converged learning as a central feature, NJIT Global will allow our on-campus students and students from other countries to attend class together, with instruction occurring here or there. Even while we build facilities overseas, converged learning allows us to commingle our student populations and benefit from instructional assets at any location, enabling us to grow beyond the limits of our current physical infrastructure in the City of Newark. This is consistent with our broad vision "to be a preeminent public polytechnic research university with local and global impact." Specifically, our strategic plan makes a clear statement that we will do this by "transforming ourselves into a global campus that innovates pedagogy and technology to advance our mission around the world." Converged learning is a cornerstone of this initiative.

Finally, as new generations of students make their way into college classrooms, many of whom have grown up in a technologically connected world, they are demanding flexibility in their learning experience. That same flexibility is also important to non-traditional learners. What is common, however, is that all students at all levels of education have experienced a significant learning deficit as a result of the sudden transition to remote learning and other serious ramifications of the pandemic. This is even more pronounced among students from disadvantaged communities who may not be as well-equipped upon entering institutions of higher education. However, a recent study suggests that children raised in communities with more "economic connectedness (cross-class interactions)" are much more likely to improve their socio-economic status, suggesting the importance of building connections among a diverse population of students (Opportunity Insights, 2022). Converged learning makes this a reality by offering a true blended community that mitigates socio-economic barriers (U.S. Department of Education, 2021).

CONCLUSION

New Jersey Institute of Technology has been at the forefront of technological and pedagogical innovation in support of teaching and learning for nearly half a century. Converged learning, which began in 2013 as a vision for an agile model for teaching and learning, was successfully used at NJIT throughout the COVID-19 pandemic. This has given us the confidence to expand our investments in this modality in alignment with our strategic vision of a global campus.

There are several other reasons though to continue pursuing such innovations. The value proposition of higher education has been under scrutiny for some time but, despite this, reform is at best nascent. While there are compelling reasons for continuing to teach and learn in traditional classrooms, it is just as clear that other modes of digital delivery have their own compelling rationales. As higher education institutions resume their strategic planning in a post-pandemic world, it is important to reflect on their recent experiences and incorporate the knowledge they acquired in order to successfully effect a necessary redesign of their learning spaces and the communities they enable.

For NJIT, converged learning is a first step in transforming how we deliver a quality educational experience to diverse learners with the flexibility to "meet them where they are." Our success in delivering

emergency remote learning reflects the deliberate creation of a flexible pedagogy and investment in technology at NJIT. Our experiences, thus, direct us to prepare for a future in higher education that seamlessly mixes face-to-face and online through a modality that extends beyond hybrid learning to offer an "anywhere classroom."

To be clear, no one is urging the total dismantling of the physical infrastructure for teaching and learning. Similarly, no one is asserting that the massive and fast-moving migration toward online education will ease once we are fully beyond the current pandemic. Thus, aligning learning theories and practices with an enabling digital component is essential for the future of effective contemporary classroom experiences for both students and faculty.

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