*The British Journal for the History of Science* (2024), 1–22
doi:10.1017/S000708742300105X

RESEARCH ARTICLE

# The 'Courant Hilton': building the mathematical sciences at New York University

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## Abstract

This essay explores how mid-twentieth-century mathematicians at New York University envisioned their discipline, cultural identities and social roles, and how these self-constructed identities materialized in the planning of their new academic building, Warren Weaver Hall. These mathematicians considered their research to be a 'living part of the stream of science', requiring a mathematics research library which they equated to a scientific laboratory and a complex of computing rooms which served as an interdisciplinary research centre. Identifying as 'scientists', they understood their societal value to be that of researchers, outputting mathematics research valuable to the natural sciences, the emerging field of computer science and the United States government and military, as well as educators. When the building opened in 1965, it was touted by the university administration as an 'example of excellence'; it later, in 1970, became the site of heated negotiations when university student and faculty protestors staged a sit-in rebuking the Atomic Energy Commission's Computing Center housed on the second floor. A close study of the correspondence between the mathematicians and their peers in the university's administration, private foundations, government agencies and an architectural firm not only illuminates the day-to-day work practices of this eminent group of mathematicians, but also sheds light on their own self-constructed academic and social identities within their contemporaneous Cold War culture.

New York University's Courant Institute of Mathematical Sciences (CIMS) has been primarily housed in Warren Weaver Hall on the university's Washington Square campus since the mid-1960s (Figure 1). Now a fixture of the vibrant downtown campus, this fourteen-storey building was the culmination of three decades of strategic institution building and development in the mathematical sciences. Under the leadership of Richard Courant (1888–1972), a German Jewish émigré mathematician, the mathematicians and affiliated researchers within CIMS at New York University (NYU) were instrumental in the conceptualization, fundraising and design of Warren Weaver Hall. According to Cathleen Morawetz, Warren Weaver Hall was dubbed the 'Courant Hilton' for its lavish size and special amenities – including an Atomic Energy Commission Computing Center, a thirteenth-floor lounge with views of the city and a comprehensive research library.[1] To the institute's faculty and students, the building served as a place for advanced-level teaching and research in mathematics and computer science. To the

[1] Cathleen Morawetz, 'The Courant Institute of Mathematical Sciences', in Peter Duren, Richard A. Askey and Uta C. Merbach (eds.), *A Century of Mathematics in America*, part 2, Providence, RI: American Mathematical Society, 1989, pp. 303–7, 306.

**Figure 1.** Richard Courant and New York University's Warren Weaver Hall, *c.* 1965. Image copyright NYU Courant Institute of Mathematical Sciences.

historian and sociologist, Warren Weaver Hall serves as a historical artefact, shedding light on the self-constructed identities of the mathematicians who designed and occupied its space.

Recent scholarship in the history and sociology of science has emphasized the reciprocal and complex relationship between the built environment and knowledge production. Studies of laboratories, hospitals, museums and field sites have illuminated how the material world can both influence and be influenced by scientific inquiry. By turning a discerning eye on the built environment, hallways become as important as lab benches for scientific collaboration; entryways and doors can serve as either welcoming structures or physical gatekeepers to science; and the geographical position of a building can alter its users' proximity, and thus interaction with, other disciplines and institutions.[2] Peter Galison claims that since architecture can 'help us position the scientist in cultural

[2] Peter Galison and Emily Thompson (eds.), *The Architecture of Science*, Cambridge, MA: MIT Press, 1999; Stuart W. Leslie, '"A different kind of beauty": scientific and architectural style in I.M. Pei's Mesa Laboratory and Louis Kahn's Salk Institute', *Historical Studies in the Natural Sciences* (2008) 38, pp. 173–221; Scott G. Knowles and Stuart W. Leslie, '"Industrial Versailles": Eero Saarinen's corporate campuses for GM, IBM, and AT&T', *Isis* (2001) 92, pp. 1–33; Thomas F. Gieryn, 'What buildings do', *Theory and Society* (2002) 31, pp. 35–74; Gieryn, 'A space for place in sociology', *Annual Review of Sociology* (2000) 26, pp. 463–96; T.J. Allen and A.R. Fustfeld, 'Research laboratory architecture and the structuring of communications', *R & D Management* (1975) 5, pp. 153–64. Important literature focusing more on the geographical place and locality of knowledge production includes David N. Livingstone and Charles W. Withers (eds.), *Geography and Revolution*, Chicago: The University of Chicago Press, 2010. For more on locality and mathematical research cultures see Moritz Epple, 'Kulturen der Forschung: Mathematik und Modernität am Beginn des 20. Jahrhunderts', in Johannes Fried and Michael Stolleis (eds.), *Wissenskulturen: Über die Erzeugung und Weitergabe von Wissen*, Frankfurt am Main: Campus Verlag, 2009, pp. 125–58.

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

space … buildings serve both as active agents in the transformation of scientific identity and as evidence for these changes'.[3]

In addition to considerations of the built environment itself, studies of the conceptualization and design processes of the ideal workplace provide sociological and historical insight into the identities of those who employ the space. As Thomas Gieryn suggests, before a place can be built, its users must first be imagined. When considering the sociological significance of buildings for science, Gieryn suggests, 'Built places materialize identities for the people, organizations, and practices they house. Through their very existence, outward appearances, and internal arrangements of space, research buildings give meanings to science, scientists, disciplines, and universities – for those who work inside and for those who just pass by.'[4]

But what of the mathematical sciences? In this paper, I turn our attention to the world of academic mathematics and computer science by analysing NYU's Warren Weaver Hall, which was designed to house the Courant Institute of Mathematical Sciences. By studying the NYU mathematicians and computer scientists – who were instrumental in raising the funds for and designing their own academic workplace – we learn more about the work practices, social roles and self-constructed cultural identities of these mathematicians. For what purposes did this group of mathematicians want their own academic building? When applying for funding from government organizations and philanthropic organizations, how did they articulate the value of their discipline? How did these imagined work practices and social roles materially translate into the planning of an ideal built environment designed to optimize advanced-level research and teaching in the mathematical sciences? A close analysis of the conceptualization, fundraising, design and habitation processes of this built workspace offers insight into these questions – and thus the collective identity of these mathematicians. This essay explores the mathematicians' own self-constructed identity as they presented themselves – and their work practices, social roles and scientific contributions – to their contemporaries in the government, the military, philanthropic organizations, academia and architecture. Such an analysis will serve as a contribution to the fields of architecture and science and the cultural history of mathematics and computer science, as well as further situating these fields within the broader history-of-science literature.[5]

It is evidenced that the NYU mathematicians in the mid-twentieth century were concerned that their contemporaries in academia, private foundations and the government, at times, misunderstood the practical realities and societal value of doing research-level mathematics. Much was at stake in terms of fundraising and prestige. Thus the NYU mathematicians were adamant in articulating the scientific value of their work, describing mathematics as a 'living part of the stream of science'.[6] Like any other scientific discipline, research and training in advanced mathematics would require adequate facilities for the full development of a scientific community. Although they requested individual offices to

[3] Peter Galison, 'Buildings and the subject of science', in Peter Galison and Emily Thompson (eds.), *The Architecture of Science*, Cambridge, MA: MIT Press, 1999, pp. 1–25, 3. Also see Maria Rentetzi, 'Designing (for) a new scientific discipline: the location and architecture of the Institute für Radiumforschung in early twentieth-century Vienna', *BJHS* (2005) 38, pp. 275–306.

[4] Thomas F. Gieryn, 'Two faces on science: building identities for molecular biology and biotechnology', in Galison and Thompson, op. cit. (3), pp. 423–55, 423.

[5] Amir Alexander, 'The skeleton in the closet: should historians of science care about the history of mathematics?', *Isis* (2011) 102, pp. 475–80; Jeremy Gray, 'History of mathematics and history of science reunited?', *Isis* (2011) 102, pp. 511–17; Tony Mann, 'History of mathematics and history of science', *Isis* (2011), 102, pp. 518–26.

[6] New York University, Courant Institute of Mathematical Sciences brochure, 1965, held in the administrative offices of New York University's Courant Institute of Mathematical Sciences, Department of Mathematics, 251 Mercer Street, New York, NY.

allow for undisturbed concentration, they also described their need for spaces in which to openly collaborate, such as a common lounge area, a research library and a state-of-the-art computing centre. Such shared spaces, they argued, would serve both intellectual and social purposes – much like a scientific laboratory.

The precise work practices of these mathematicians – as both researchers and teachers – placed specific demands on the built environment. Particular attention was placed on the proper lighting of blackboards in the classrooms; faculty offices needed to have close proximity to the library; and all workspaces required isolation from the noise of street traffic, students shuffling between classes and the building's boiler. Office furnishings included not only desks, chairs and bookshelves, but also high-quality blackboards and, in some cases, sofas as an aid to deep contemplation.

The institute's ideological identity as a scientific research and teaching institute was largely derived from its founder, Richard Courant, and his formative experiences at the University of Göttingen in Germany as a student, and later professor and director of its Mathematics Institute, from the 1910s to the early 1930s.[7] Courant's time as a student in Göttingen under the administrative leadership of Felix Klein and as an assistant to David Hilbert shaped his understanding of an ideal mathematics research institute on both administrative and intellectual levels. Academically, Klein and Hilbert immersed a younger generation of mathematicians and physicists, including Courant, in the long, rich mathematical tradition of Göttingen.[8] The Göttingen Mathematics Institute espoused specific intellectual values: approaching the mathematical sciences broadly and inclusively of pure and applied realms, building close relations with physical scientists, collaborating with industrialists and combining research with advanced teaching.[9]

[7] For more on Richard Courant's scientific identity in the Cold War see Brit Shields, 'Mathematics, peace, and the Cold War: scientific diplomacy and Richard Courant's scientific identity', *Historical Studies in the Natural Sciences* (2016) 46(5), pp. 556–91. For more on Richard Courant's life and career see Constance Reid, *Hilbert–Courant*, New York: Springer-Verlag, 1986 (first published 1970). Also see Brit Shields, 'A mathematical life: Richard Courant, New York University and scientific diplomacy in twentieth century America', doctoral dissertation, University of Pennsylvania, 2015.

[8] Since the University of Göttingen was founded in 1734, many prominent mathematicians have been on its faculty, including, famously, Carl Friedrich Gauß, Peter Gustav Lejeune Dirichlet, Bernhard Riemann, Felix Klein and David Hilbert. A rich secondary literature on the history of the Göttingen mathematics tradition includes Norbert Schappacher, 'Das Mathematische Institut der Universität Göttingen 1929–1950', in Heinrich Becker, Hans-Joachim Dahms and Cornelia Wegeler (eds.), *Die Universität Göttingen unter dem Nationalsozialismus: Das verdrängte Kapitel ihrer 250jährigen Geschichte*, Munich: K.G. Saur, 1987, pp. 344–73. A revised version can be found online; see Norbert Schappacher, 'Das Mathematische Institut der Universität Göttingen 1929–1950', at https://irma.math.unistra.fr/~schappa/NSch/Publications_files/GoeNS.pdf (April 2000) (last accessed 11 May 2023); David E. Rowe, '"Jewish mathematics" at Göttingen in the era of Felix Klein', *Isis* (1986) 77, pp. 422–49; and Rowe, 'Klein, Hilbert and the Göttingen mathematical tradition', *Science in Germany: The Intersection of Institutional and Intellectual Issues*, *Osiris* (1989) 5, pp. 186–213. For more on the general development of mathematical cultures in Germany (and elsewhere) see Rowe, 'Disciplinary cultures of mathematical productivity in Germany: 1855–1933', in Volker R. Remmert and Ute Schneider (eds.), *Publikationsstrategien einer Disziplin: Mathematik in Kaiserreich und Weimarer Republik*, Wiesbaden: Harrassowitz Verlag, 2008, pp. 9–51; and Rowe, 'Mathematical schools, communities, and networks', in Mary Jo Nye (ed.), *The Cambridge History of Science*, vol. 5: *Modern Physical and Mathematical Sciences*, Cambridge: Cambridge University Press, 2003, pp. 113–32. For more on Göttingen and its scientific tradition see Nicolaas A. Rupke (ed.), *Göttingen and the Development of the Natural Sciences*, Göttingen: Wallstein-Verlag, 2002; and Renate Tobies, 'Wissenschaftliche Schwerpunktbildung: Der Ausbau Göttingens zum Zentrum der Mathematik und Naturwissenschaften', in Bernhard von Brocke and Jürgen G. Backhaus (eds.), *Wissenschaftsgeschichte und Wissenschaftspolitik im Industriezeitalter: Das 'System Althoff' in historischer Perspektive*, Hildesheim: Edition Bildung und Wissenschaft, Verlag A. Lax, 1991, pp. 87–108.

[9] For more on the University of Göttingen's Mathematics Institute see the works cited in note 8. Additional secondary literature includes Winfried Scharlau, 'Göttingen, Universität', in Scharlau (ed.), *Mathematische Institute in Deutschland 1800–1945*, Braunschweig: Vieweg and Teubner Verlag, 1990, pp. 117–28; Leo Corry, 'David Hilbert and the axiomatization of physics (1894–1905)', *Archive for History of Exact Sciences* (1977) 51,

Administratively, assuming the organizational notion of an institute rather than an academic department has direct lineage to the German university system. The specific design requirements – and even the general concept of a building devoted solely to the research and training of mathematics – originated with Klein's inventive, yet never realized, designs for a mathematics building in Germany dating to the 1910s.[10] Following his doctorate, Courant served in the First World War and then joined the faculty of the University of Münster. He returned to Göttingen in 1921. Courant continued these Göttingen academic and administrative traditions as a professor and particularly following his appointment as successor of Klein as the director of Göttingen's Mathematics Institute in 1920, as detailed by Rowe and Siegmund-Schultze.[11] His own work spoke not only to mathematicians, but also to physicists; he published the famous text *Methoden der mathematischen Physik* with Hilbert in 1924, offering a lucid presentation of the mathematics later found informative to quantum mechanics.[12] Although Klein did not live to see it, Courant revived the plans to construct a building to house the institute. Courant's placement within the elite Göttingen mathematics and physics community shaped the endeavour. The Rockefeller Foundation had already established connections with the institute by way of funding fellowships through its International Education Board. On the suggestion of Courant's close friends and colleagues Niels and Harald Bohr, he was also able to secure funds from the Rockefeller Foundation to build the Mathematics Institute building which opened in the late 1920s.[13] This experience cemented Courant's critical personal contacts with an American private foundation.

Following Courant's dismissal by the Nazis in April 1933, he spent months sorting through the ambiguity of his official status.[14] As Siegmund-Schultz details, Courant ultimately accepted a one-year appointment at the University of Cambridge, while his family remained in Germany.[15] Originally hopeful that he could return to the Göttingen faculty, Courant eventually joined the faculty of NYU in the autumn of 1934. Prior to Courant's arrival, NYU was little known among Europeans and certainly was seen as far secondary to other American universities with strong programmes in mathematics, such as Princeton University, the University of Chicago, and Harvard

pp. 83–198; and Saunders MacLane, 'Mathematics at Göttingen under the Nazis', *Notices of the AMS* (1995) 42(10), pp. 1134–8.

[10] For more on Courant's personal memories of his time in Göttingen and his ideas on the history of scientific development there (and elsewhere) see Richard Courant, 'Reminiscences from Hilbert's Göttingen', *Mathematical Intelligencer* (1981) 3(4), pp. 154–64; Courant, 'Mathematical education in Germany before 1933', *American Mathematical Monthly* (November 1938) 45(9), pp. 601–7; and Reid, op. cit. (7). Courant often cited the legacy of the Ecole polytechnique on the development of scientific institutions more broadly. See Peter D. Lax, *Richard Courant 1888–1972: A Biographical Memoir*, Washington, DC: National Academy Press, 2003. Note that New York University also established an Institute of Fine Arts in the mid-1930s. The Institute of Advanced Study also serves as an example of the institute organizational model.

[11] David E. Rowe, *A Richer Picture of Mathematics: The Göttingen Tradition and Beyond*, Cham: Springer, 2018; and Reinhard Seigmund-Schultze, *Mathematicians Fleeing Nazi Germany: Individual Fates and Global Impact*, Princeton, NJ: Princeton University Press, 2009.

[12] Richard Courant and David Hilbert, *Methoden der mathematischen Physik*, Berlin: Springer, 1924.

[13] For more on the University of Göttingen's Mathematics Institute building see Otto Neugeubauer, 'Das mathematische Institut der Universität Göttingen', *Die Naturwissenschaften*, 3 January 1930, pp. 1–4; Reinhard Siegmund-Schultze, *Rockefeller and the Internationalization of Mathematics between the Two World Wars: Documents and Studies for the Social History of Mathematics in the 20th Century*, Basel: Birkhäuser Verlag, 2001; Robert E. Kohler, *Partners in Science: Foundations and Natural Scientists, 1900–1945*, Chicago: The University of Chicago Press, 1991.

[14] For more on the complex process of Courant's dismissal from Göttingen see Reinhard Siegmund-Schultze, *Mathematiker auf der Flucht vor Hitler: Quellen und Studien zur Emigration einer Wissenschaft*, Braunschweig and Wiesbaden: Vieweg, 1998; and Seigmund-Schultze, op. cit. (11).

[15] Siegmund-Schultze, op. cit. (13), pp. 167–70.

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

University.[16] After difficult and incremental institutional building efforts in the 1930s, the tides changed for NYU mathematics – along with many academic departments across the country – with the Second World War. Establishing itself as a major player in the Office of Scientific Research and Development's Applied Mathematics Panel, NYU's mathematicians propelled themselves into the post-war and Cold War military–industrial–academic complex.[17] The growing group of mathematical scientists – now including computer scientists – saw ample funding from the Office of Naval Research, the Atomic Energy Commission and private foundations, among other sources. When the time came in the 1960s to raise funds for and design Warren Weaver Hall at NYU, the Göttingen Mathematics Institute served as a symbolic model in two important ways: first as an exemplar of an ideology of mathematics being integral to the physical sciences, and second as having a unique building for mathematics research and teaching.[18] The real-estate constraints of downtown Manhattan, a growing NYU student population and a supercomputer computing centre would never allow for the reconstruction of the sprawling, three-storey Göttingen Mathematics Institute. Nonetheless, as we will see, Courant espoused these experiences in Göttingen as a mechanism to establish prestige among funding sources, as well as to display an understanding of the social and architectural elements conducive to fostering a thriving scientific community. Ultimately, Courant's vision for the institute and its own building were buoyed by the generous Cold War sponsorship by government agencies, private foundations and university sources in the 1960s. When Warren Weaver Hall opened in 1965 it emerged as a decades-long manifestation of these profound social, political and academic forces.

## Architecture and mathematics

A number of buildings devoted solely to teaching and research in advanced-level mathematics were constructed at the same time as the University of Göttingen's (1929) and New York University's (1965) mathematics institutes. The 1920s and 1930s saw the construction of the Institut Henri Poincaré in Paris (1928), the University of Chicago's Eckhart Hall (1930) and Princeton University's Fine Hall (1931). The buildings' roles in creating a mathematics community at these institutions have been described to varying degrees by both mathematicians and historians. The contribution of Fine Hall to Princeton's, and later the Institute of Advanced Study's, community of mathematicians in the early twentieth century, for example, was examined closely by William Aspray. Oswald Veblen, who was primarily responsible for Fine Hall's realization, Aspray argues, ‘recognized its potential value in nurturing a mathematics community’ and even opted to have Fine Hall physically connected by a corridor to the Palmer Laboratory of Physics to foster interaction beyond just the mathematicians.[19]

Reinhard Siegmund-Schultze discusses the ‘cooperation between mathematicians and Rockefeller philanthropists in dealing with problems of international communication in mathematics in the decades before World War II’ – which spans issues such as travelling fellowships, scientific publications and communications between disciplines.[20] Within this

[16] Karen Hunger Parshall and David E. Rowe, *The Emergence of the American Mathematical Research Community, 1876–1900: J.J. Sylvester, Felix Klein, and E.H. Moore*, Providence, RI: American Mathematical Society, 1994, pp. 435–9.

[17] Mina Rees, ‘The mathematical sciences and World War II’, *American Mathematical Monthly* (1980) 87, pp. 607–21.

[18] Courant, ‘Reminiscences from Hilbert's Göttingen’, op. cit. (10).

[19] William Aspray, ‘The emergence of Princeton as a world center for mathematical research, 1896–1939’, in Peter Duren (ed.), *A Century of Mathematics in America*, part II: *History of Mathematics*, vol. 2, Providence, RI: American Mathematical Society, 1989, pp. 195–215.

[20] Siegmund-Schultze, op. cit. (13), pp. 20–6.

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

context, Siegmund-Schultze describes the way in which the Rockefeller Foundation came to sponsor the construction of both the Göttingen Mathematics Institute and the Institut Henri Poincaré in Paris.[21] Siegmund-Schultze puts forth a detailed account of how and why the Rockefeller Foundation came to be involved in these mathematics buildings projects as part of a larger strategy to improve international mathematics communications in the interwar period. Robert Kohler took an 'ecological approach' in describing the Rockefeller Foundation's decision to support both these projects, pointing to its International Education Board's 'strategy of developing university systems by making their peaks higher'.[22]

Much less has been written in the secondary literature specifically about the buildings devoted to mathematics teaching and research in the 1960s, such as New York University's Warren Weaver Hall (1965) and the new Fine Hall (1969) on Princeton's campus. The latter building, designed by the same architectural firm as Warren Weaver Hall, is, however, referenced in some mathematicians' anecdotal essays.[23] Calvin C. Moore offers a detailed account of Evans Hall at the University of California, Berkeley, within the historical context of the development of Berkeley's mathematics department.[24] I aim to add to this scholarship through this study of Warren Weaver Hall, the mathematics and computer science building at New York University.

## Warren Weaver Hall: the Courant Institute of Mathematical Sciences at New York University

### *Early institution building in the mathematical sciences at NYU, prior to Warren Weaver Hall*

Courant's ties with the Rockefeller Foundation – dating back to the 1920s with their sponsorship of the Göttingen Mathematics Institute's building as well as the International Education Board fellowship programme – would continue to play a profound role throughout his career and in his institutional building efforts in the US. Funding from the Rockefeller Foundation through the auspices of the Emergency Committee in Aid of Displaced German (later Foreign) Scholars enabled his placement within New York University. The Rockefeller Foundation's director of the Division for Natural Sciences, Warren Weaver, was particularly critical in the committee's negotiations, as well as the foundation's salary subsidy that allowed for the position.[25] Weaver would continue to play a vital role in Courant's career and NYU's growth in mathematics. As a mathematician himself, Weaver was a former University of Wisconsin–Madison student of Max Mason, mathematician and current president of the Rockefeller Foundation. Mason was a former student of David Hilbert, thus linking him to Courant through their shared Göttingen intellectual lineage.[26]

When Courant arrived at NYU for the 1934–5 academic year, he found what was described as a 'desert' of mathematics, but only when compared to the vibrant mathematics cultures that he had experienced at both Cambridge and Göttingen.[27] The NYU Graduate Department of Mathematics listed Courant as a visiting professor in the

[21] Siegmund-Schultze, op. cit. (13), pp. 143–77.
[22] Kohler, op. cit. (13), pp. 162–3.
[23] See Steven G. Krantz, 'Mathematical anecdotes', *Mathematical Intelligencer* (Fall 1990) 12(4), pp. 32–8.
[24] Calvin C. Moore, *Mathematics at Berkeley: A History*, Wellesley, MA: A.K. Peters, Ltd, 2007, pp. 219–36.
[25] Shields, op. cit. (7).
[26] Siegmund-Schultze, op. cit. (13), pp. 188–9.
[27] Courant's student, Peter D. Lax, described Courant's impression of New York University as a 'desert' of mathematics. See Lax, op. cit. (10).

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

1934–5 annual bulletin, along with six other faculty members and a lecturer.[28] After two years with visiting status, Courant was finally guaranteed a permanent place on the NYU faculty and became the head of the Graduate Department of Mathematics.

Amidst the economic depression of the 1930s, Courant, with the assistance of his staff, particularly Flanders and Putnam, and later the American mathematician James J. Stoker and the German émigré mathematician Kurt O. Friedrichs (who both joined the faculty in 1937), endeavoured to build an eminent graduate mathematics centre by emulating the ideals of the Göttingen Mathematics Institute. According to David Rowe,

> The Göttingen tradition had gone underground; like so many other remnants of Weimar culture, it reemerged a short time later in the United States. There Hermann Weyl joined Albert Einstein at the IAS, Emmy Noether taught at Bryn Mawr until her unexpected death in 1935, and Richard Courant gave the Göttingen tradition its most lasting reincarnation by founding a mathematics institute at NYU.[29]

Courant consistently credited Klein's and Hilbert's influence on him in striving to nurture interdisciplinary research, primarily between mathematics and physics; in stressing the importance of combining research with advanced teaching; and in fostering a sense of community within the mathematics group at NYU. Jane Richtmyer, the representative for 'space matters' at the NYU Institute of Mathematical Sciences, reflected in 1961 that 'Courant, who had previously been director of the Mathematics Institute at Göttingen, Germany, brought with him to this country the point of view that mathematics is an integral part of science; and also that research and graduate training are an organic whole in which each reinforces the other.'[30]

During the early decades, the Graduate Mathematics Department – later Institute – was housed in a variety of accommodations on or around NYU's downtown Washington Square campus. The mathematicians' appeals to the university administration for more space and a proper library devoted to mathematics, however, had begun shortly after Courant's arrival. As early as 1935, Courant, Flanders and Putnam drafted a memo to distribute among university administrators, private foundations and industry leaders in an attempt to raise funds for the Graduate Mathematics Department. They specified that the 'ideal thing and ultimate goal would be to have a comparatively independent institution', with its own building, library, faculty offices, space for students to work, classrooms for seminars and lectures and a collection of mathematical models and instruments.[31] It would be three decades before the group moved into such a building. Similar to the Göttingen mathematics community, the construction of its own building came long after – and perhaps was only feasible because of – a clear demonstration of success in research publications, fundraising and doctoral training. Instead, the group managed a series of ad hoc accommodations. The *New York Times* recounted in its coverage of Warren Weaver Hall's dedication ceremony in 1965, 'Staff members swapped tales of the old days in a hat factory, a Bible-publishing loft and the Judson Memorial Church.'[32] Some of the

[28] New York University, Graduate School of Arts and Sciences, bulletin, 1934–5, collection of course bulletins MC.286, New York University Archives, Box 189.

[29] Rowe, '"Jewish mathematics" at Göttingen in the era of Felix Klein', op. cit. (8), p. 449.

[30] Eleazor Bromberg to Martin Beck, 27 October 1961, Records of the Office of the University Architect/Joseph J. Roberto Collection, New York University Archives (subsequently ROUA), Box 21, Folder 2.

[31] Richard Courant, Donald A. Flanders and Robert G. Putnam, 23 December 1935, 'Memorandum concerning a graduate department of mathematics at New York University', Records of the Office of the President (Harry Woodburn Chase), New York University Archives (subsequently NYU Chase), Box 36, Folder 2.

[32] 'Math center dedicated at N.Y.U.', *New York Times*, 30 March 1965, p. 49.

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

mathematics faculty worked downtown on or near the Washington Square campus; others, particularly those affiliated with the undergraduate mathematics programme (when it was separated from the graduate programme) in the early years, worked uptown at NYU's University Heights campus in the Bronx. Courant relinquished a University Heights office that he shared with Flanders after just a few years, claiming that he spent all of his time on the downtown campus. The group spent the war years and early post-war years on the Washington Square campus, at 53 Washington Square South, later relocating to the Fourth Avenue location near Astor place, about a half-mile away.[33] By the late 1950s, the growing staff were splintered between two academic buildings which were divided by several city blocks. Most of the faculty offices and the AEC computing centre were located at 25 Waverly Place, while the rest of the faculty offices were in 4–6 Washington Place, both very near Washington Square.[34]

The NYU mathematics community had a material existence beyond the university campus. From the time of his arrival in New York, Courant resided with his wife and four children in New Rochelle, New York, about eighteen miles from NYU's Washington Square campus, in a comfortable home where he had two offices and a yard. Other faculty members were encouraged to live in New Rochelle as well and to visit the Courant home as guests for musical concerts, for dinner or to enjoy the garden, providing a space for community building outside the NYU campus.[35] In fact, Courant and many of his colleagues were not only known to work indoors in a library or office, but often received inspiration from their time outside such spaces. In an unpublished *New Yorker* profile of Courant, journalist Morton Hunt describes Courant's 'research' process eloquently. Hunt writes,

> The word [research] usually summons to mind the tedious cliché of a man in a white smock, pouring, filtering, adjusting, or otherwise doing something to something. Courant works unsmocked, equipped at most – but not always – with pad and pencil, or chalk and chalkboard. He has done some of his life's work at desks, but much more in bed, or while playing the piano, skiing, driving, or walking.[36]

Indeed this Romantic concept of doing brilliant mathematical work while outside the typical office was reinforced in Courant from his days in Göttingen, studying under Hilbert. As his biographer Constance Reid reports, Courant remembered watching Hilbert alternate between gardening, riding his bicycle and working on a twenty-foot-long blackboard he had installed in his garden. Reid quoted Courant's impression of Hilbert's research process: 'A fantastic balance between intense concentration and complete relaxation'.[37] As in Göttingen, Courant evoked this tradition of working both inside and out, and both on campus and off, during his time at NYU. This notion of mathematical research being portable, requiring only a brilliant mind and perhaps some paper or a blackboard, however, was not the dominant image that Courant and his colleagues wanted to portray when it came time to raise funds for a new academic building. A place for social and intellectual interaction for both research and teaching was equally vital. They met the challenge to demonstrate that a truly thriving community of mathematicians – like any other scientific community – would require space for contact among faculty and students.

33 See correspondence in NYU Chase, Boxes 34, 48, 59.

34 Sidney G. Roth to Louis Levin, 3 October 1960, ROUA, Box 21, Folder 1.

35 'Eyewitness accounts', during the symposium, 'Turmoil and transition – tracing émigré mathematicians in the twentieth century', 1 October 2013, Deutsches Haus, New York University.

36 Morton Hunt, 'Courant profile: directions for knowing all dark things', *New Yorker*, unpublished article, 29 December 1961, Rare Books and Manuscripts Division, *The New Yorker* Records, Sub-series 6.3, New York Public Library, Box 1457, Folders 14–15.

37 Constance Reid, *Hilbert*, New York, Heidelberg and Berlin: Springer-Verlag, 1970, p. 109.

## *Fundraising*

By the early 1960s, the NYU mathematicians possessed both the demand for – and the means for financing – a university building devoted solely to research and teaching in graduate-level mathematical sciences. The accumulating Cold War desires among US government officials for an expansive scientific workforce, exacerbated by the Soviet launch of Sputnik in 1957, provided the fertile soil in which to plant their seeds. Other scientific disciplines, such as material science, were utilizing the abundance of government funding for the growth of their research and training efforts, including the construction of new buildings.[38] Mathematicians similarly were seeking extra-institutional support not just for research and training, but also for new buildings. At NYU, the researchers within the mathematical sciences – spanning a large swath of research agendas including pure mathematics, mathematical physics and computer science – positioned themselves as scientists, clearly articulating their value to applied problems.

Within the contexts of the military–industrial–academic complex and the growing university system across the United States, NYU also set out on its own university-wide mission to grow in prestige. The funds available from private, government and military sponsors were abundant and the institute's leadership thought that the time to build its own home had arrived. At this time, in the early 1960s, there were over 250 researchers and staff connected with the institute, including over 210 scientists and graduate students in mathematics, physics, chemistry and engineering.[39] In early discussions of the need for new space, Sidney G. Roth, an NYU research services coordinator from the Office the Executive Vice President, carefully referred to the IMS researchers as 'scientists' to the NSF. He expressed the scientific justification for improved space:

> With the division of scientific personnel between two buildings, we became concerned over the scientific functioning of the Institute. The separation imposed hardships which could be corrected only through physical unity … In effect, there is a real possibility that with NSF [National Science Foundation] and private foundation support, the University will be able to utilize its budgetary resources for the creation of a significant scientific research center at Washington Square.[40]

Following Courant's retirement from teaching in 1958, Stoker assumed the directorship of the institute. During his retirement, Courant remained on the board of the newly named Courant Institute of Mathematical Sciences and was intimately involved in the fundraising for and design of Warren Weaver Hall.

Throughout the process of fundraising for the expansion of space, the mathematicians and administrators responsible for the grant proposals and requests were consistent in emphasizing the scientific importance of physically uniting all of the components of the Institute of Mathematical Sciences, as well as creating close physical proximity to other scientific disciplines on campus, particularly physics. In their grant applications, they consistently expressed the scientific value of their research, which could be heightened through unified quarters. Prior to seeking funds for the construction of an entirely

[38] See, for example, Hyungsub Choi and Brit Shields, 'A place for materials science: laboratory buildings and interdisciplinary research at the University of Pennsylvania', *Minerva* (2015) 53(1), pp. 21–42; and Cyrus C.M. Mody and Hyungsub Choi, 'From materials science to nanotechnology: interdisciplinary center programs at Cornell University, 1960–2000', *Historical Studies in the Natural Sciences* (2013) 43(2), pp. 121–61.

[39] 'Request for matching funds to provide for the unification and planned development of the research facilities of the Institute of Mathematical Sciences', proposal to the National Science Foundation, 3 October 1960, ROUA, Box 14, Folder 1.

[40] Roth, op. cit. (34).

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

new building, the mathematicians originally sought to renovate space at 4–6 Washington Place and the contiguous 707 Broadway. In a request to the National Science Foundation (NSF) for such renovations, they stated, 'The Institute of Mathematical Sciences has long had a tradition and atmosphere of free scholarly exchange among its staff and students. The physical separation of some of the divisions of the Institute in recent years has somewhat inhibited this exchange of scientific information.'[41] They sought space which could accommodate the entire staff, including offices, a mathematics library, lecture halls and colloquium rooms for its thirty faculty, sixty non-faculty research scientists and over a hundred full-time graduate students, as well as twenty engineers and forty administrative, technical and office employees. They reiterated the importance of ready access to other scientific disciplines on campus:

> It is likely that within the near future these relationships with the Physics Department, the College of Engineering and other University scientific groups will increase. One of the purposes of this request is to make possible this cross-departmental activity within the organic entity of the Institute, thereby breaking down the artificial barriers between departments.[42]

In a separate proposal to the NSF for the relocation of the institute, it was again expressed that the scientific value of the institute justified physical expansion: 'Professor Courant's emphasis was upon the need to identify mathematics, not only as an abstract form or discipline, but as the key to the important problems of the physical and biological sciences.'[43]

It was not long before the institute's mathematicians decided to pursue constructing an entirely new building. In June of 1961, they requested funds from the Sloan Foundation, directing their letter to Alfred P. Sloan. They articulated that the purposes of the building 'would, at once, facilitate scientific work, improve faculty morale, and serve as a handsome architectural embodiment of this unique enterprise'. The unique enterprise to which they were referring was 'the faculty of IMS [including] mathematicians, physicists, engineers and statisticians', which operated on a $2.7 million research budget sponsored in large part by federal contracts and grants. They added that the new building would be named Warren Weaver Hall, in honor of the former Rockefeller Foundation officer and Applied Mathematics Panel director, who was currently serving as the Sloan Foundation's vice president and trustee.[44]

The NYU mathematicians further addressed the 'scientific justification' for a new building, in terms of both scientific research output and training, in their 1962 application to the National Science Foundation for the Graduate-Level Research Facilities Development Grant. They reported that their staff had grown to include, as of February 1962, 280 individuals, including sixty faculty members, seventy-five research scientists, over a hundred full-time graduate fellows and assistants, twenty computer engineers, and forty technical and administrative staff members. The research areas of each of the four divisions of the institute were detailed. Mathematics and Mechanics consisted of 'a broad research program in pure and applied mathematics, e.g., analysis, algebra, partial differential equations, etc.' The Electromagnetic Research division focused on 'electromagnetic radiation and upper atmosphere ionization, atomic and molecular physics including quantum physics'. The Atomic Energy Commission Computing and Applied Mathematics Center, which was then operating an IBM 7090, focused on 'numerical methods, computation techniques,

41 'Request for matching funds …', op. cit. (39).
42 'Request for matching funds …', op. cit. (39).
43 Roth, op. cit. (34).
44 George D. Stoddard to Alfred P. Sloan Jr, 14 June 1961, ROUA, Box 21, Folder 2.

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

computer design, and application of large-scale computational processes to problems of science and technology'. Finally, the Magneto-fluid Dynamics Division was described as doing research 'in plasma physics and magneto-hydrodynamics'.[45]

Further demonstrating the scientific – and particularly applied – nature of their work, the mathematicians reported on the research output of the faculty and students, as well as the institute's budget and financial sponsors. A detailed list of 'Research Support of the Courant Institute of Mathematical Sciences' for the 1961–2 academic year included the research areas and principal investors for six grants from the Office of Naval Research, three grants from the Army Office of Ordnance Research, seven grants from the Air Force, five grants from the National Science Foundation, four grants from the Atomic Energy Commission, and single grants from the National Aeronautics and Space Administration and the American Petroleum Institute, totalling approximately $2.8 million of outside funding. The grants depict the diverse array of research conducted at the institute. The largest sponsor, the Atomic Energy Commission, supported $1,793,000 worth of grants for the operations of the AEC Computing and Applied Mathematics Center, including research projects in computer design and the development of computer components, as well as applications such as magneto-fluid dynamics and plasma physics. The Office of Naval Research sponsored over $300,000 of grants to support research in applied mathematics, hydrodynamics, probability and electromagnetic theory. The National Science Foundation similarly sponsored about $300,000 worth of research, largely for work in electromagnetic theory, as well as combinatorial group theory and mathematical physics. The Air Force supported nearly $300,000 worth of grants for research in electromagnetic theory, as well as ordinary and partial differential equations, special functions and integral equations. The Army Office of Ordnance Research, NASA and the American Petroleum Institute sponsored smaller grants for research in fluid dynamics and perturbation theory, electromagnetic physics in outer space and acoustic-wave propagation respectively.[46] Finally, they reported on the credentials of each faculty member – listing their degrees, academic positions, honours and publications. They specified that the institute had awarded eighty-one doctoral degrees over the past five years, detailing the names of recent graduates and their dissertation titles.[47]

In this NSF grant application, the mathematicians consciously sought to employ architecture as a way to foster scientific collaboration, claiming, 'A central meeting place for relaxed, free interchange of information is not just a convenience; it is a necessity.'[48] First, a new building would provide nearly double the amount of space the institute currently had – an increase from 63,000 gross and 35,200 net square feet to 112,500 gross and 75,000 net square feet. They emphasized the scientific nature of the space, planning for not only offices, classrooms and colloquium rooms, but also a research library, a 'computing machinery laboratory' and an 'engineering laboratory.' They approximated the proportions of room allocated to the different functions of the institute, breaking down the space as 80 per cent designated for 'basic research and research training' and 20 per cent for 'graduate and undergraduate instruction'. The larger 80 per cent devoted to research and research training included 50 per cent offices for staff, 5 per cent seminar and colloquium rooms, 9 per cent research library, 8 per cent computing laboratory, 6 per

[45] Application for National Science Foundation graduate-level research facilities development grant, 28 February 1962, ROUA, Box 21, Folder 3.

[46] Application for National Science Foundation graduate-level research facilities development grant, op. cit. (45).

[47] Application for National Science Foundation graduate-level research facilities development grant, op. cit. (45).

[48] Application for National Science Foundation graduate-level research facilities development grant, op. cit. (45).

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

cent engineering laboratory and offices and 2 per cent storage. This breakdown suggests that these mathematicians wanted to portray themselves to their potential sponsors as scientific researchers, needing both individual and shared workspaces.

The NYU mathematicians were successful in raising $2.3 million from the Sloan Foundation, $1 million from the Ford Foundation, and $900,000 from the NSF toward the construction of the new building, which ultimately cost $6,350,000. Additionally, the Sloan and Ford Foundations also contributed $750,000 for fellowships and research in the mathematical sciences.[49] The institute continued to receive substantial research and fellowship support from other heavy-hitting government sponsors such as the AEC and ONR. The AEC, for example, while not contributing towards the building costs, did continue to sponsor the large computing centre that would be housed in the new building, which persisted as a substantial part of the institute's annual research budget. The building itself thus became a physical manifestation of the funding structures of the military–industrial–academic complex. Also, naming the new building after Warren Weaver was the culmination of Courant's decades-long comradery with the foundation's administrator–mathematician.

Warren Weaver Hall was employed by the university administration as an emblem of their expansion efforts in the 1960s. The *New York Times* reported that the building's construction was part of a larger $75 million fundraising programme for NYU, of which $17.25 million had been designated for the construction of classrooms on the Washington Square campus. Warren Weaver Hall was to be the first new building of this 'classroom center project'. The *New York Times* coverage reiterated the uniqueness and magnitude of the NYU Courant Institute, pointing to its $3.2 million total annual budget.[50]

## Design

The mathematicians at NYU were just as instrumental in the design of Warren Weaver Hall as they were in its fundraising. A study of the design process allows further insight into their understanding of the ideal workplace, reflecting their perceptions of their own discipline and work practices, as well as their concern for the perception of the scientific value of their work. Forming a 'Space Committee', the mathematicians clearly articulated their thought-out requirements of the new building to the university architects, Martin Beck and Joseph Roberto, and later to the external architectural firm, Warner, Burns, Toan & Lunde, describing their work practices to the architects as a balance of individual and community research. They stressed not only the very important need for private offices for the faculty members, but also the necessity for common, shared spaces where faculty and students could engage in 'natural' discussions and collaborations. Mathematician Eleazor Bromberg, apparently concerned about a misconception of mathematicians working in 'aloof isolation', sought to clarify that this group of researchers saw an intellectual value in community spaces:

> One of our major desires in connection with space is to provide our staff with the kind of quiet and freedom from distraction that is essential for concentration, and at the same time, to make it easy for them to meet and talk to each other, so as to yield a maximum of interplay. This means that we should like to have one-man offices, or accommodations as far as this is possible, arranged in larger units

[49] 'Fact sheet regarding Warren Weaver Hall', New York University Office of Information Services, 28 March 1965, ROUA, Box 22, Folder 23.

[50] 'University to match money donated for math unit', *New York Times*, 26 October 1961, p. 27.

> which will encourage the establishment of group interactions to a considerable extent.[51]

Bromberg emphasized that it was essential for each faculty member to have a private office, with space to accommodate a desk, blackboard, bookcase, filing cabinet and couch for visitors. Beyond individual private offices for the faculty, he listed the library as the 'second concern', followed thirdly by a 'lounge for staff and students'. Bromberg also specified that the new building should include four to six classrooms of varying sizes, and an elevator, reception area, mail distribution centre and switchboard. If they were to share any of their accommodations with another department, he suggested that it be the Physics Department, as they had 'not worked closely with any other group'.

This notion of both private/individual and public/shared spaces being critical was by no means unique to the mathematicians at NYU. In fact, the Conference Board of the Mathematical Sciences, funded by the Educational Facilities Laboratories of New York and the Ford Foundation, worked on a Project for the Design of Buildings and Facilities for Mathematics, Statistics, and Computing. The Harvard University-trained mathematician and faculty member of Michigan State University J. Sutherland Frame, who had visited many domestic and international places of mathematical instruction, teaching and research for this project, circulated a summary of proceedings of a conference the board had held in December of 1961.[52] The *Proceedings from the Conference on the Design of Buildings and Facilities for the Mathematical Sciences*, which were distributed to the NYU group during their planning of Warren Weaver Hall, reflected upon the work practices of research mathematicians and how they shaped their space needs:

> A discussion of space for research must be prefaced by an understanding of how a mathematician does research. Typically, a mathematician must prepare for his research by (1) reading in the library, (2) hearing lectures and talks by other mathematicians, (3) discussing mathematics with colleagues, and (4) thinking for extended periods about his problems. Often the result he finally publishes is not the one he was originally looking for, but some by-product seen in a moment of inspiration. After the preparation, stimulation, and inspiration comes a period of elaboration in which ideas are developed, checked in the literature to see if similar results have been published, and polished into publishable form – preferably with secretarial help. Mathematical research is concerned with the creative development of ideas, and the way a mathematician works at his research follows from this fact.[53]

Similarly to the NYU institute's mathematicians, Frame felt the need to specifically articulate the work practices of mathematicians to their peers in other fields, such as architecture and university or government administration. Frame's choice of emphasized verbs – reading, hearing, discussing and thinking – consisted of both individual and collaborative endeavours. Frame added that a 'common room or lounge, equipped with overstuffed furniture', where teas for faculty and students could be arranged, would 'facilitate the exchange of ideas among mathematicians'.

By making the comparison to the critical need for a scientific laboratory in the natural sciences, Frame emphasized the importance of an up-to-date, readily accessible research library, stocked with books and research journals, for mathematicians. Frame described

[51] Eleazor Bromberg to Martin Beck, 27 October 1961, ROUA, Box 21, Folder 2.

[52] J. Sutherland Frame to Mathematics Department chair, 15 January 1962, ROUA, Box 21, Folder 2.

[53] *Proceedings from the Conference on the Design of Buildings and Facilities for the Mathematical Sciences*, 8–9 December 1961, ROUA, Box 21, Folder 2, underlining original.

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

the mathematics library as 'as essential to the researcher in mathematics as the experimental room or laboratory is to the experimental physicist or chemist'.[54] The critical importance of shared spaces, including the library and lounge, and their utility in both intellectual research developments and community building, mirrored Klein's original conception of a mathematics building as articulated by Courant. As remembered by the Rockefeller Foundation officer August Trowbridge, while applying for funds from the Rockefeller Foundation for the Göttingen Mathematics Institute in the 1920s, Courant had argued that

> something like a laboratory – with research rooms, central library, etc. would do for mathematics what the building of physical laboratories for research had done a generation or more ago … The present tendency was for the mathematicians to miss the frequent contacts which any laboratory students naturally get with their fellow students.[55]

Indeed, in the 1960s the desire to create space for intellectual and social interaction among the faculty and students remained dominant.

With regard to the individual offices, certain specifications regarding the lighting, acoustics and furnishings were also detailed in the *Proceedings*, which suggest a particular ideal built environment for mathematicians. Frame wrote, 'A mathematician should be provided with a private office or study, adequately lighted, heated, air-conditioned, and acoustically insulated, and equipped with a large chalkboard and comfortable furniture.' These demands imply that the mathematicians preferred a controlled environment – not for running sensitive physical experiments, but rather for comfortable, undisturbed concentration. He continued,

> If a comfortable easy chair or sofa is an aid to stimulating creative thought, it is not really a luxury. In fact, a mathematician's most important work – thinking creatively – may be done best in a posture that suggests inactivity to those who work primarily with their hands. Most (and possibly all) German universities provide a sofa for every full professor of mathematics. There a full professor of mathematics typically has a private office of about 270 square feet (25 square meters), and persons of lesser rank have offices two-thirds as large.[56]

Offices should be equipped with a desk, several chairs for visitors and bookcases. These offices should 'be removed from direct proximity to classrooms, but not too far away that a professor can't drop into his office between classes', and should be in close physical proximity to the mathematics library.[57] Frame's descriptions of these space needs – and thus the implied work practices of research mathematicians – as well as the reference to the German university as the conceptual ideal, concur with the NYU's mathematicians' descriptions and consequential architectural requirements.[58] Like Frame, the NYU mathematicians had to clearly articulate why both private and shared spaces were critical to a thriving mathematical community.

54 *Proceedings*, op. cit. (53).

55 August Trowbridge log regarding Göttingen trip, cc Wickliffe Rose, 2 July 1926, International Education Board Records, Rockefeller Foundation Records, RAC.

56 *Proceedings*, op. cit. (53).

57 *Proceedings*, op. cit. (53).

58 The NYU architect, Martin L. Beck, replied to Frame in response to the proceedings requesting additional copies. Martin L. Beck to J. Sutherland Frame, 23 February 1962, ROUA, Box 21, Folder 2.

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

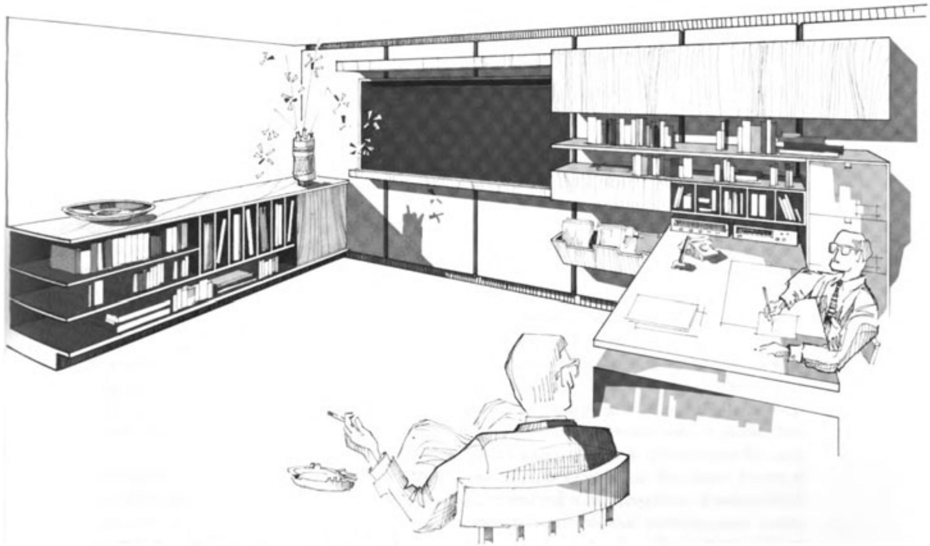

FIGURE 29 *Design for a professor's office*

**Figure 2.** 'Design for a professor's office', as depicted in J. Sutherland Frame, *Buildings and Facilities for the Mathematical Sciences*, Washington, DC: Conference Board of the Mathematical Sciences, 1963, p. 75. Image copyright Conference Board of the Mathematical Sciences. Note that bookshelves, a large desk, a visitor's chair, a pencil (or pen) and paper and a blackboard are all depicted. The mathematicians themselves are depicted as being in a conversation, demonstrating the communicative nature of their work.

Throughout the *Proceedings* text, the male-gendered pronouns he, him and his were consistently used, implying the assumed gender of most university mathematicians. Additionally, in the sketched image of the professor's office, the academic mathematicians were depicted as male (Figure 2). While some of the Courant Institute mathematicians were women (and some, albeit few, women were depicted in the *Proceedings* text), the discipline remained largely composed of mathematicians who were men in the 1960s. This gender disparity was reflected in a large proportion of specifically men's restrooms in the plans for Warren Weaver Hall.

The following January, NYU's Chancellor George Stoddard called for a planning conference in which the university architects Beck and Roberto were in attendance. At the conference, an idea of placing Warren Weaver Hall and (a never-built) science building on either side of a general classrooms building was discussed. Stoddard reiterated the value of close physical proximity between the institute and the proposed science building.[59] In March 1962, the newly established Governing Council of the Courant Institute of Mathematical Sciences held its first meeting. It was reported that Warner, Burns, Toan & Lunde – known for their work on the Sloan–Kettering Institute – were selected for the architectural work of Warren Weaver Hall.[60]

Also in March 1962, the space committee outlined a floor-by-floor description of the building's intended uses, as well as general remarks to consider. The bulk of the floors were to be devoted to advanced-level research, including individual faculty offices, a

[59] Institute for Mathematical Sciences Planning Conference minutes, 8 January 1962, ROUA, Box 21, Folder 2.

[60] Minutes of the Governing Council of the Courant Institute of Mathematical Sciences, 5 March 1962, Administrative Papers of Chancellor/Executive Vice President Sidney Borowitz, New York University Archives, Box 61, Folders 12–16.

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

colloquium room and a lounge, connected by a large corridor, divided in two sections, a 'large common room and smaller adjoining room for semi-privacy'. The library was to have its own floor, built to accommodate an anticipated hundred readers during the peak hours of 4–8:30 p.m. and to hold over 30,000 volumes.

The second and third floors were to accommodate the Atomic Energy Commission computing centre. During the early 1960s, the AEC was sponsoring over half of the institute's annual research budget. While the AEC was not financially involved in the building's construction, the physical demands of the computer centre played a critical role in its design. The supercomputer would be installed on the second floor, which required 'special consideration of floor strength in connection with the installation of computing machinery'. The computing centre was to consist of a machine room, engineers' room, keypunch room, ready room, operator's room and visitors' work room. The third floor was to hold the computing centre personnel's offices, a seminar room and small kitchenette. The remaining space was to be devoted to teaching, including classrooms on the lower floors. Space for administrative activities appropriate for the size of the Courant Institute was also requested, including administrative offices, a mail centre, a large reception area and a switchboard room.[61]

Special accommodations for the Atomic Energy Commission's computing laboratory included a heightened ceiling and 'floating floor' to allow for cables to run underneath, additional office space for the computing personnel and a series of task-specific rooms and offices. During much of the design of the new building, it was anticipated that they would be operating their IBM 7090 computer in the new building. By the time Warren Weaver Hall opened in January 1965, the AEC Computing Center had acquired a newer CDC 6600 computer and auxiliary equipment, parts of which were moved by crane into the building through a window on the second floor.

Beyond the new supercomputer, perhaps the most critical pieces of equipment for the mathematicians were the blackboards.[62] Indeed, in mathematics, the utility of the blackboard is manifold – operating at times as a research tool, at other times as a paedagogical tool, and sometimes in both capacities simultaneously. Its importance was reflected in the accommodations in Warren Weaver Hall. Of the $405,500 furnishings budget, $26,000 was reserved for high-quality blackboards.[63] The floor plans of various office types all included the particular placement of the blackboards.[64] They were to be installed at a specific height, so the mathematician could use the entire board. The architects had a detailed schedule for the installation of each blackboard.[65] The classrooms contained layers of blackboards, which would roll on a suspended levy system to allow instructors the use of up to sixteen slates, each measuring eight feet wide by four feet tall.[66] Having multiple blackboards for class instruction would allow the professor to continue lecturing while leaving the course material on the board for students to examine and transcribe.

Beyond the allocation of space and equipment for the various activities of the mathematicians, particular requests for the acoustic, thermal and visual environment of the

[61] Courant Institute of Mathematical Sciences Space Committee to the Architects of Warren Weaver Hall, 19 March 1962, ROUA, Box 21, Folder 2. The architectural needs of the institute in this document were very similar to those listed in a document from the previous November, also in the architect's records. 'Notes on requirements in new building', 17 November 1961, ROUA, Box 21, Folder 2.

[62] For a detailed study of the material culture and tools employed in mathematical research see, for example, Peggy Aldrich Kidwell, Amy Ackerberg-Hastings and David Lindsay Roberts, *Tools of American Mathematics Teaching, 1800–2000*, Baltimore, MA: Johns Hopkins University Press, 2008.

[63] Memo to Mr Robinson regarding furnishings budget, 8 April 1964, ROUA, Box 21, Folder 16.

[64] Floor plans, 28 April 1964, ROUA, Box 21, Folder 16.

[65] Chalkboard schedule, 29 April 1964, ROUA, Box 21, Folder 16.

[66] Room data sheets, 30 June 1965, ROUA, Box 10, Folder 10.

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

entire building were detailed. Such attention to detail regarding the built environment indicates that this group of mathematicians envisioned themselves as engaging in work that demanded a high level of concentration, and thus a high level of control over their environment. Their ideal built environment included acoustically controlled classrooms and offices, properly lit blackboards, efficient elevators and hallways, and convenient proximity between research materials and private and public workspaces. They requested that partitions between corridors and offices should be solid, not partially glass. All 'special rooms should have temperature controls'; the air conditioning in the classrooms 'must be noiseless'; it was preferable for the classrooms to be on the western side of the building, further from the distracting loud street traffic; the stairways should be well lit and amply wide, as they are 'frequently used by staff to go up or down several flights'. 'Exceptionally good elevator service' was also required, anticipating a 'large influx of students at beginning of term'. Additionally, it was pointed out that the traffic to the library would be heavy. Finally, one elevator should have freight capacity.[67] It was noted by the architects that the 'tenants of the building will be very conscious of any noise and they have specifically voiced their concern about being annoyed, particularly in the classrooms, by noises emanating from the central heating plant', which was to be installed underneath the building.[68] In fact, acoustic consultants were brought in to estimate the noise levels of the boiler room in Warren Weaver Hall.[69]

## Habitation

As the researchers began occupying the newly opened Warren Weaver Hall, the university administration, as well as the mathematicians, were simultaneously engaged in establishing the social identities of the CIMS researchers through media and publicity materials. A critical component of this collective identity continued to be that of scientists, reinforcing their identity as a body of scientific researchers collaborating, teaching and producing research of scientific importance. In other words, they were deliberately breaking down the false stereotype of mathematicians working in isolation from each other and from currents in science. Furthermore, the eminence of this particular group of researchers was celebrated by the university and employed to further the expansion plans of NYU.

Shortly after its opening in 1965, Warren Weaver Hall won eight awards for excellence from the New York State Association of Architects.[70] The fourteen-storey building (including a top floor accessible only for maintenance) had approximately 120,000 square feet of space. Key features included the 251 research offices, several large auditoriums on the ground floor, an additional four seminar rooms, a colloquium room on the thirteenth floor, a second-floor computing facility with a 'floating floor' to accommodate electronic cables, a lounge on the thirteenth floor running the length of the building, and a library on its own floor holding 32,000 volumes and periodicals and surrounded by twenty 'cantilevered glass-enclosed bays around the perimeter'.[71] The NYU Office of Information Services touted the institute as 'the largest center for mathematical training and research in the Western world'.[72]

[67] Courant Institute of Mathematical Sciences Space Committee, op. cit. (61).

[68] Warren Weaver Hall was constructed in tandem with a central heating plant that rested underneath the building. Robert Burns to Joseph E. Schober, 15 November 1962, ROUA, Box 21, Folder 2.

[69] Laymon N. Miller to Robert Burns, 3 December 1962, ROUA, Box 21, Folder 2.

[70] 'N.Y.U. hall wins design honor', *New York Times*, 3 January 1965, p. R1.

[71] 'Fact sheet regarding Warren Weaver Hall', op. cit. (49).

[72] Alan Kohn, press release, New York University Office of Information Services, 28 March 1965, ROUA, Box 22, Folder 23.

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

As the building was put to use for the research and teaching of advanced-level mathematics, NYU's administration continued to employ the institute as a symbol of the university's own development. Messaging meticulously described the value of the scientific research being conducted. A March 1965 advertisement for NYU in the *New York Times* entitled 'an example of excellence' featured a large photograph of Warren Weaver Hall, alongside NYU president James J. Hester's description of the institute and Courant:

> Here he found the freedom, encouragement, and resources to establish what has now become an international center for advanced training and research in the mathematical sciences. The development of the Courant Institute demonstrates the benefits of collaboration of private university, government, and private philanthropy … The range of research interests among the members of the Institute is broad, extending from purely mathematical questions in group theory and functional analysis to applied mathematical problems involved in attempts to diminish the height of flood-wave crests on the Ohio River and in efforts to control thermonuclear fusion reactions for the peaceful use of atomic energy.[73]

The NYU administration employed Warren Weaver Hall as a tangible, visual representation of the academic endeavour of mathematics research and teaching at NYU, as well as the physical manifestation of Courant's decades-long institutional building efforts within the changing political, cultural and economic contexts of the mid-twentieth century.

Notably, however, the press also reiterated themes carefully cultivated by the Courant Institute mathematicians in their fundraising efforts, such as a congenial, collaborative atmosphere and – crucially – a robust combination of training and advanced research. A *New York Times* 'Week in education' article, for example, began by describing the Courant Institute's daily afternoon teas in the thirteenth-floor lounge:

> One of the longest coffee breaks of academia, it is also one of the most productive. It is an informal seminar of mathematicians and physicists, open to all ranks from students to senior professors. The 'teas' (as the coffee break is referred to in continental fashion) are typical for procedures established by Dr. Richard Courant … His disciple–successors made it clear last week that the scholarly informality will be retained even in its new home.[74]

Warren Weaver Hall's dedication ceremony was similarly described by the *New York Times* as being 'more like a family gathering than a formal ceremony'. Senator Jacob K. Javits commented that there was an increasing conflict between research and teaching responsibilities of a university, adding, 'The Government is somewhat at fault in balancing the academic scales in favor of research over teaching. We face something of a crisis in American education that calls for redressing the balance.' He commented that the Courant Institute was unusual in its commitment to both teaching and advanced-level research, adding that in the past decade it had awarded close to two hundred doctorates.[75]

The Courant Institute itself published an annual brochure, starting in 1965, which described its academic programmes and research. The first volume featured a picture of the new building on its cover, as well as a series of professional photographs of the mathematicians in the building. The composition of these staged photographs – and

73 'Advertisement: display ad 36', *New York Times*, 26 March 1965, p. 36.
74 Fred M. Hechinger, 'Week in education', *New York Times*, 28 March 1965, p. E9.
75 'Math center dedicated at N.Y.U.', op. cit. (32).

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

**Figure 3.** The Courant Institute of Mathematical Sciences published an annual brochure describing its research and graduate training programmes starting in 1965. The images in the first brochure included two exterior photographs of Warren Weaver Hall, an NYU campus map, and these six photographs of NYU mathematicians. In each of these photographs, selected for inclusion in the brochure, the mathematicians are depicted as engaging in conversation, collaboration or a lecture. Top left, Kurt O. Friedrichs and Richard Courant in Courant's garden at his home in New Rochelle, NY, p. 2. Top right, James J. Stoker, speaking in front of a blackboard, p. 4. Middle left, Eleazer Bromberg, Stoker and Louis Nirenberg, p. 11. Middle right: Peter D. Lax (left), Robert D. Richtmyer (right) and unknown (sitting) in the Computing Center, p 12. Bottom left, Harold Grad and Cathleen Morawetz, p. 14. Bottom right, Jerome Berkowitz and Jacob Schwartz in the lounge, p. 17. Image copyright NYU Courant Institute of Mathematical Sciences.

their selection for inclusion in the brochure – further emphasized the self-constructed identity of this group of mathematicians as they understood themselves and wanted to be understood (Figure 3). The images include groups or pairs of mathematicians collaborating in an office, in the computing centre, in the library and in the lounge. The one image which depicted just a single mathematician, James J. Stoker, actually suggested that he is either lecturing or speaking to someone else. Another image showed Courant and Stoker working in Courant's garden in New Rochelle, again emphasizing that the tight-knit mathematics community extended beyond the NYU campus. These images – which were consciously selected and edited – demonstrate that the mathematicians and the

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

administrators who compiled the brochure sought to present the mathematicians' work practices as social and collaborative.[76]

As evidenced by the success of the institute in building Warren Weaver Hall in 1965 – during which time the institute maintained a $2.8 million research budget 'supported by various government agencies, foundations, and companies', a staff of (reportedly in 1965) forty-five faculty, sixty-five postdoctoral fellows, 125 pre-doctoral research fellows and two hundred full-time graduate students – it is arguable that this group of mathematicians were successful in cultivating the cultural identity and social role that they sought as a community of research scientists. There were some minor growing pains on moving into the new building: for example, it was noted that 'the Courant Institute people have never been happy with the blackboard lighting in the two north classrooms and the colloquium [room]'. Lighting consultants were brought in to conduct tests, which determined that fluorescent lighting worked better with the blackboards than incandescent lighting.[77] Additionally, there were limits to what they could do to control their identity and the societal implications of their work. Being sponsored by numerous government and military organizations during the Cold War and physically housing an Atomic Energy Commission supercomputer in their building created a liability for the institute.

Most significantly, in May 1970 – just days following the US invasion of Cambodia and the tragic shooting of four Kent State University students by the National Guard – there were strikes among NYU students and student occupations of several buildings on NYU's campus.[78] Among the buildings occupied was Warren Weaver Hall. The $3.5 million AEC supercomputer – or what was being called by the strikers 'the war machine' – was held to ransom by the students for $100,000 – money they intended to use as bail to release a member of the Black Panthers Party from jail. Members of the Courant Institute faculty and staff were sympathetic with the students' anti-war stance and tried to peacefully negotiate the release of the computer and the building. After days of occupation and negotiations within Warren Weaver Hall, the strikers finally decided to release the computer, opting to hold a press conference and 'denounce the computer's presence on campus'. As the hundreds of student strikers left the building, one physics student and one history professor lit a fuse to a bomb device on the second-floor computing facility, an attempt that was thwarted by two young mathematics professors who muffled the fuse at the last moment.[79]

This dramatic incident demonstrates that the Courant Institute was regarded as part and parcel of the Cold War academic–military–industrial complex, and that negotiations over the societal value and role of their scientific work literally took place within Warren Weaver Hall. Ultimately, the records indicate that the Cold War-era mathematicians at the Courant Institute of Mathematical Sciences understood themselves – and wanted to be understood – in a very specific way. Their participation in war-related research and government-funded research served as both credential and validation of their scientific output, but also carried with it a complicated set of issues related to the ethics of scientific research which ultimately were negotiated within the walls of Warren Weaver Hall.

[76] Courant Institute of Mathematical Sciences brochure, op. cit. (6).

[77] Robert Burns to Joseph Schober, 4 November 1965, ROUA, Box 22, Folder 2.

[78] Thomas J. Frusciano and Marilyn H. Pettit, *New York University and the City: An Illustrated History*, New Brunswick, NJ: Rutgers University Press, 1997, pp. 235–6.

[79] New York University's News Bureau published a report on the occupations of the university buildings. 'The disruptions at Loeb, Courant and Kimball: a report to the New York University community on the occupation of three buildings at Washington Square during the Cambodian crisis period of May 1970', 23 September 1970, New York University Archives, Records of the Office of the President (Dr James McNaughton Hester), RG 3.0.7; 76; 13.

https://doi.org/10.1017/S000708742300105X Published online by Cambridge University Press

## Conclusion

New York University's Courant Institute of Mathematical Science's Warren Weaver Hall was specifically designed for study, teaching and research in advanced-level mathematics. A study of Warren Weaver Hall as the physical manifestation of decades of institutional building efforts in mathematics at NYU can inform us about the self-constructed and self-imagined disciplinary identity, work practices and social roles of the mathematicians who designed and occupied the building. The NYU mathematicians clearly articulated the *scientific* value of their research efforts; maintained that they partook in both *individual* and *community* work practices; and demonstrated their *research*, *training*, and *teaching* capacities through governmental and military contract work, running a doctoral programme and offering courses of instruction. This emphasis on scientific value was critical as they consistently described their work as emphasizing both pure and applied mathematics, and later computer science, and distinguishing themselves from any notion that their work in mathematical theory was unattached from scientific applications. Additionally, they identified their educational legacy as stemming from the institute's founder, Richard Courant, and the traditions of the Göttingen Mathematics Institute, as developed by Felix Klein and David Hilbert. These institutional and disciplinary identities presented themselves in what these mathematicians considered to be the ideal built environment, consisting of office space, classrooms, colloquium rooms, a lounge, a computing centre and a comprehensive research library.

Throughout the fundraising and design processes for Warren Weaver Hall, the NYU mathematicians consistently demonstrated the scientific utility of their work and their identity as a community of researchers. The mathematics library was described as a 'necessity', understood to function as an intellectual and social equivalent of a scientific laboratory. Perhaps anxious that they would be misunderstood as preferring to work in 'aloof isolation', the mathematicians consistently described their work practices as being both individual and community endeavours, involving reading each other's work, discussing problems and attending regular seminars. These work practices translated into the need not only for individual offices, but also for shared workspaces in the design of the new building. Space for students and faculty to enjoy academic collaboration took form in the thirteenth-floor lounge, classrooms and seminar rooms. Architecture was employed – with both private and shared spaces – as a way to enable productive scientific researchers and to foster interaction among the community of academic mathematicians. The mathematicians were also aware of their roles on campus as teachers – who needed large lecture halls for undergraduate instruction – as well as mentors and advisers responsible for the advanced-level training of the next generation of research mathematicians.

Studying Warren Weaver Hall as a historical artefact demonstrates how this group of mathematicians portrayed themselves as a collaborative group of scientific researchers – conducting contractual work for the government, training new mathematicians and teaching collegiate mathematics. These disciplinary identities and social roles were at times affirmed, as evidenced by the financial support from the National Science Foundation, private foundations and government agencies. At other times, particularly during the 1970 student protests, the societal merits of their work, and thus these very identities, were challenged. In all, the built environment of Warren Weaver Hall, placed in its historical context, offers insight into these evolving, negotiated and self-constructed identities of this group of mathematicians.

**Cite this article:** Shields B (2024). The 'Courant Hilton': building the mathematical sciences at New York University. *The British Journal for the History of Science* 1–22. https://doi.org/10.1017/S000708742300105X