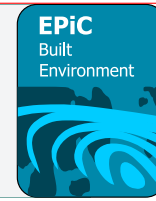




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Construction Research and Interdisciplinarity: Insights from NSF-Funded Awards

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This paper analyzes trends in construction-related research awards and the inclusion of an interdisciplinary approach in the United States National Science Foundation (NSF) awarded research. The data included in this paper is from the NSF fiscal years from 1985 to 2024. The need for an interdisciplinary approach in construction research has been well-argued in research publications. An interdisciplinary approach in research emphasizes addressing research problems by teams or individuals that integrate information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines. In this paper, the NSF-funded awards that include the word “construction” in the title or abstract are analyzed into four categories: “construction” and “management” awards, “construction” and trending topic awards, “construction” and “workforce” awards, and “construction” and “education” awards. The data was further analyzed to investigate the occurrence of the word “interdisciplinary” in the title or abstract. The results show that the number of interdisciplinary awards in these four categories ranged from 3.7% to 13.1%, and the awarded amount ranged from 3% to 16.5% of the total awards in the respective categories. The study offers a comprehensive, longitudinal evaluation of interdisciplinarity in NSF-funded construction research in the United States.

Keywords: Construction management, Construction research trend, Interdisciplinary, NSF funding, Workforce

Introduction

Baccalaureate and higher degree programs in construction management (CM) are growing and the programs have established themselves as independent programs with unique identity. Although CM programs in the universities started as a branch within the already existing branches of Engineering and Architecture, the programs have established themselves as a distinct academic area (Hauck, 1998 and Rounds, 1992). Along with the growth of teaching and learning in construction management, the programs have championed research in the field of construction and related areas. A lot of research has been done in the past to explore and analyze trends in research articles in construction management. For example, Hong, Chan, Chan, and Yeung (2012) did a critical analysis of published literature to explore the number of “partnering” related publications during 1987-2007. A similar research was conducted by Larsen, Ussing, and Brunø (2013) to analyze publication trend of construction research in journals. Similarly, in a trends analysis using text mining of construction management journal papers from 2000 to 2020, Bilge and Yaman (2021) found that “building

information modeling,” “information management,” “scheduling and cost optimization,” and “lean construction” were among the trending topics.

As construction management research continues to expand in both volume and thematic diversity, and as construction projects increasingly involve complex challenges spanning fields such as engineering, architecture, environmental science, social science, technology, and management, an interdisciplinary approach to construction research becomes instrumental in addressing these challenges. By combining knowledge from multiple disciplines, researchers can develop more comprehensive and effective solutions to these multifaceted problems, ultimately improving project outcomes and advancing the field. The need for an interdisciplinary approach in construction research has been well-argued in research publications. Based on empirical studies and literature reviews, Ceric (2014) provides a theoretical framework for interdisciplinary research in inter-firm, intra-firm, and interpersonal trust in construction projects. Similarly, O'Brien, London, and Vrijhoef (2004) argue that industrial organization and analytic modeling cannot provide a comprehensive picture of the supply chain issues in construction. They consider interdisciplinary research necessary to adequately provide normative theory and methods to improve such issues from both a policy and managerial level.

Recognizing the growing scholarly consensus on the importance of interdisciplinary research, funding agencies in the public sector increasingly encourage interdisciplinary approaches in the research they support. For example, the U.S. National Science Foundation (NSF) prioritizes research that is interdisciplinary, extending beyond the boundaries of a single discipline or program. The Institute of Medicine (2005) defines interdisciplinary research as a “mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice” (p. 2). Against this background, the main objective of this research is to analyze the inclusion of an interdisciplinary approach in construction-related research awarded by the NSF during 1985-2024. The main research questions that this research aims to answer are:

- What is the trend of interdisciplinary approach in construction management research?
- What is the trend of interdisciplinary approach in construction workforce research?
- What is the trend of interdisciplinary approach in construction education research?

Research Data and Processing

The data for this research was downloaded as .xml files from the NSF website using the advanced search function. The data was obtained by using the keyword “construction” to search in the titles and abstracts of the research awards from the fiscal year 1985 to 2024. The data was obtained by using the keyword “construction” to search in the titles and abstracts of the research awards from the fiscal year 1985 to 2024. Since the NSF uses October 1 – September 30 as the fiscal year, the search query used the original award date range from October 1, 1984, to September 30, 2024. The starting point of fiscal year 1985 was selected because records prior to that year do not consistently include abstracts, limiting the scope of content-based analysis. The analysis was limited to awards up to 2024 to maintain consistency in funding structures, as notable changes in research funding policies were introduced following the administrative transition thereafter. The downloaded data was processed in R to filter out the data outside of the date range, as some of the downloaded data contained entries from other periods. The remaining data was validated to confirm that all entries had at least one occurrence of “construction” either in the title or abstract. After filtering out anomalies, there were a total of 14,647 unique awards that had at least one occurrence of the word “construction” either in the title or abstract. A deeper analysis revealed that the downloaded data also contained awards that are not related to the field of construction practice but contain the word “construction”. For example, the

The data was further filtered into four subsets: construction management, construction trends, construction workforce, and construction education, as shown in Table 1. The first subset of data includes awards that have the words “construction” and “management”, referred to hereafter as “construction AND management” awards. The second subset includes awards containing the words “construction” and one word from the list of construction trend words. This list of trending words comprises the trending cluster topics from Bilge and Yaman (2022) and the top research topical areas from Abudayyeh, Dibert-DeYoung, and Jaselskis (2004). Bilge and Yaman (2022) analyzed 3,335 journal articles published between 2000 and 2020 and found that “building information modeling”, “information management”, “scheduling and cost optimization”, “lean construction”, “agile approach”, and “megaprojects” were trending topics in the construction management literature. Abudayyeh, Dibert-DeYoung, and Jaselskis (2004) analyzed 18 years of publications between 1985 and 2002 from the American Society of Civil Engineers’ Journal of Construction Engineering and Management. They found that the top topical areas were related to scheduling, productivity, constructability, simulation, cost control, planning, safety, and computer systems. The complete list of trending topics in construction is given in Subset 2 in Table 1. The second subset of data was obtained by filtering the awards so that titles or abstracts have at least one occurrence of the words “construction” and one of the words from the list of trending topics. This subset is referred to hereafter as “construction AND trend words” awards for further discussion.

Table 1. Data summary and list of “Trending” words

Subset	Category name			
Subset 1: filtering word is “management”	“construction AND management” award			
Subset 2: filtering word is one of the trend words below from references Bilge and Yaman (2022) and Abudayyeh, Dibert-DeYoung, and Jaselskis (2004) (* - “construction” was added to give specific context)	“construction AND trend words” award			
“agile approach”		“bidding”	“construction equipment”	“*construction planning”
“building information modeling”		“bridge construction”	“estimating”	“*construction productivity”
“information management”		“build operate transfer”	“highway construction”	“*construction risk”
“lean construction”		“computer systems”	“construction innovation”	“*construction safety”
“megaproject”		“concrete construction”	“international construction”	“*construction simulation”
“scheduling and cost optimization”		“contracting”	“*construction management”	“*construction scheduling”
		“contractors”	“*construction management”	“tunnels”
		“cost control”	“*construction optimization”	“*construction technology”
		“construction education”	“*construction performance”	
Subset 3: filtering word is one from the list “craftsperson”, “craftspeople”, “craftsmen”, “crews”, “laborers”, “tradesman”, “tradespeople”, “workers”		“construction AND workforce” award		
Subset 4: filtering word is “education”		“construction AND education” award		

The third subset includes awards containing the words “construction” and workforce-related words in the title or abstract, referred to hereafter as “construction AND workforce” awards. The workforce-related words include commonly used terms such as craftsperson, worker, crews, etc. The complete list of words related to the workforce is shown in Subset 3 in Table 1. The last subset includes awards with the words “construction” and “education” either in the title or abstract, referred to hereafter as

“construction AND education” awards. The analysis focuses on the number of unique awards and total awarded amount in each category.

Construction and management awards

There are a total of 871 “construction AND management” awards that have at least one occurrence of both the words “construction” and “management” in the title or abstract. The number of “construction AND management” awards and the awarded amount in comparison to “construction” awards are shown in Figure 2. Although the amount of “construction AND management” awards was up to 20% and 30% during the fiscal years 1990-94 and 2005-09, respectively, the average amount during 1985-2024 is 15.3%. The number of such awards, however, is nearly constant at 10%.

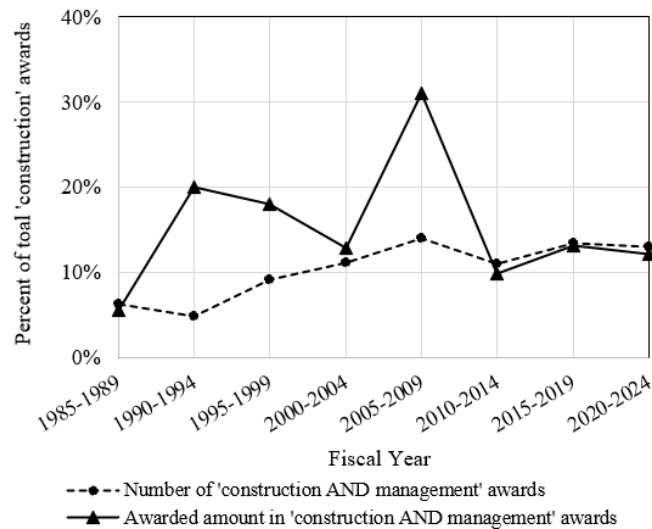


Figure 2. Awards with words “construction” and “management”

In order to investigate interdisciplinary consideration in the “construction AND management” awards, the data was further filtered to analyze the number of awards that mention “interdisciplinary” in the title or abstract (Figure 3). Figure 3 shows the percentage of awards with the word “interdisciplinary” in comparison to “construction AND management” awards. The number of “interdisciplinary” awards increased from 5% to 18% during fiscal years 1995-2009 but declined again to below 10%. Although the awarded amount peaked during the fiscal years 2000-2004 and 2010-2014 at 31.8% and 27%, respectively, the average over the period of 1985-2024 is around 10.7%. Overall, the number of awards in the “construction AND management” category shows a gradual, albeit modest, increasing trend over the study period. In contrast, the sharp increases observed in awarded amounts during certain fiscal periods are likely driven by one or two large-scale projects receiving substantial funding rather than by a broad-based increase in the number of awards.

Construction and trend word awards

As explained above, this category of “construction AND trend word” awards includes awards that have occurrences of the words “construction” and at least one word from the list of construction trend words (see Table 1) in the title or abstract of the awards. As seen in Figure 4 below, the number of awards in this category ranges from 5.5% to 7.5% of the total “construction” awards during the period of 1985-2024. The average percentage of awards during this period is 6.9%. The amount awarded in

this category ranges from as low as 2% to as high as 24% of the total awarded amount for the “construction” awards (see Figure 4). The average over the period from 1985 to 2024 is 8%, which is similar to the average number of awards. Unlike the moderately increasing trend in ‘construction and management’ awards (Figure 2) and ‘interdisciplinary’ awards (Figure 3), the number of awards in ‘construction’ and trending words has remained constant over time (Figure 4).

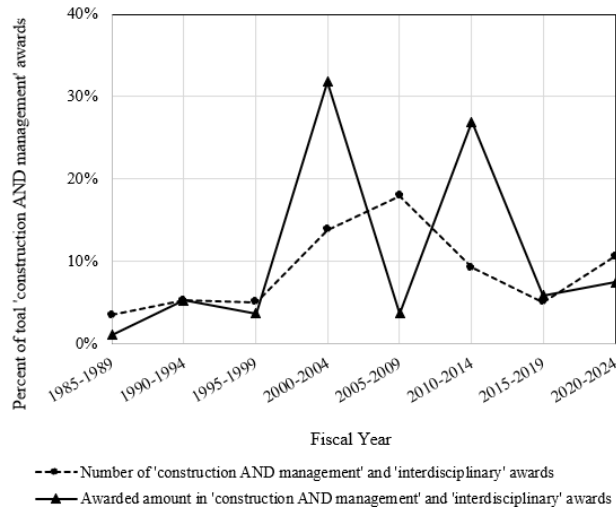


Figure 3. Awards mentioning “interdisciplinary” in “construction AND management” awards

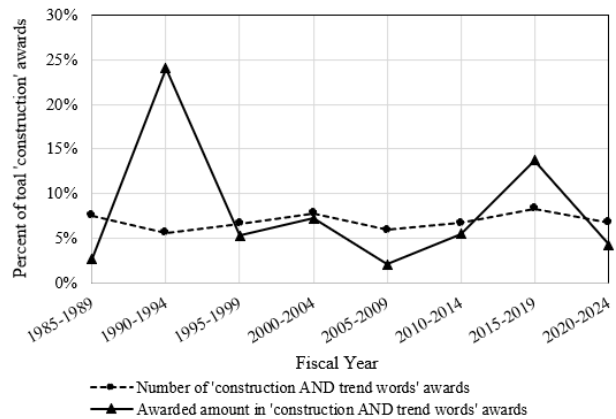


Figure 4. Awards with words “construction” and one of the words from the list of trend words

An analysis of the inclusion of the word “interdisciplinary” in this category of research is shown in Figure 5. Figure 5 depicts the percentage of the number and awarded amount of the awards with the word “interdisciplinary” in the “construction AND trend words” awards category relative to the total number and awarded amount in this category. The results show a small but increasing trend in both the number of awards and the awarded amount (Figure 5). Initially, there were no awards with the word “interdisciplinary” in the title or abstract in this category, but there has been a gradual increase over the years. The average number of awards and awarded amount during the period when the word “interdisciplinary” was present in the title or abstract, from 1994 to 2024, are 10% and 22%, respectively.

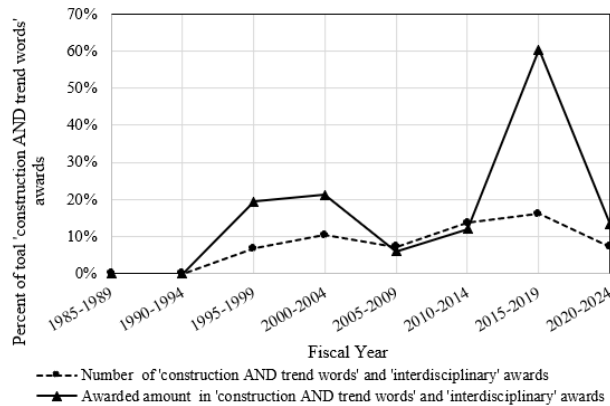


Figure 5. Awards mentioning “interdisciplinary” in “construction” and “trend words” awards

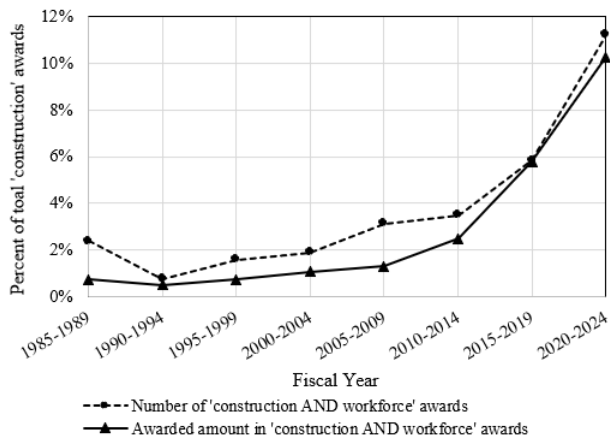


Figure 6. Awards with words “construction” and one “workforce” related word from Table 1

Workforce related awards

The awards in the “construction AND workforce” category include those that have at least one occurrence of the words “construction” and one of the workforce-related words (see Table 1) in the title or abstract. The number of awards and awarded amounts are plotted in Figure 6 as percentages of the total “construction” awards. Both the number of awards and awarded amounts show an increasing trend. The percentage of the number of awards was 2% or less before 2014, but it has increased to more than 10% in the last decade. The awarded amount in this category has also increased from about 2% or less before 2004 to about 11% during the fiscal years 2020-2024. Figure 7 shows the occurrence of the word “interdisciplinary” in this category of “construction AND workforce” awards. The analysis shows that from 1985 to 2009, there were no awards in this category with the word “interdisciplinary”. This is surprising given that workforce-related issues in construction and the wellbeing of the workforce are among the issues requiring an interdisciplinary focus. The research trend shows that after 2009, there has been a constant increase in the number of awards from 0 during 2005-2009 to 14.4% during 2020-2024. Similarly, the awarded amount increased from 0 during 2005-2009 to 10.4% during 2015-2019 and plateaued at about 10.9% during the period 2020-2024 (Figure 7).

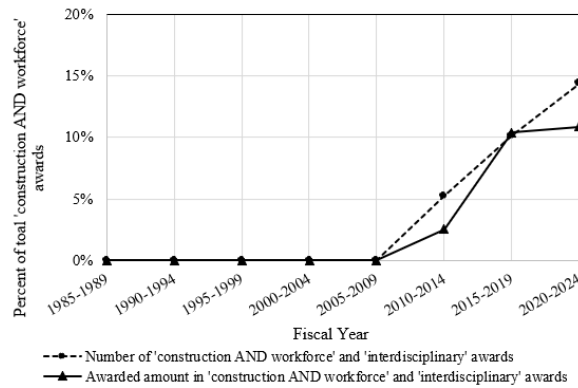


Figure 7. Awards mentioning “interdisciplinary” in “construction” and “workforce” awards

Education related awards

The fourth category of awards is related to education in construction. This category, named “construction AND education” awards, includes awards that have at least one occurrence of the words “construction” and “education” in the titles or abstracts. Figure 8 shows the number of awards and awarded amounts as percentages of the total “construction” awards. The results indicate that the number of awards in this category has increased continuously from 3.4% during 1985-1989 to 41.6% during the last five fiscal years. The average number of awards in this category is about 25% of the total “construction” awards. The awarded amount was about 40% during 1985-1989, despite the fact that the total number of awards during this period was only 3.4%. The awarded amount during 1985-2024 ranges from 34.3% during 1995-1999 to 55.1% during 2010-2014, with an average of 43.8%.

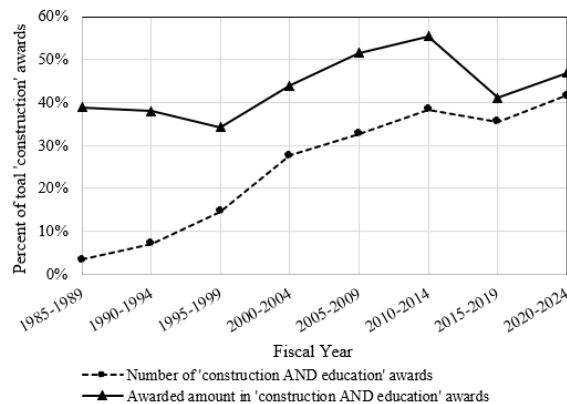


Figure 8. Awards with words “construction” and “education”

The percentage of awards with the word “interdisciplinary” in the category of “construction AND education” awards is shown in Figure 9. As seen in the figure, the percentage of awards with the word “interdisciplinary” out of the total number of awards in this category ranges from the lowest at 5.3% to the highest at 17.1% during the fiscal years 1990-1994 and 1995-1999, respectively. The average number of awards in the “construction AND education” category with the word “interdisciplinary” during 1985-2024 is 13.1% of the total awards in this category. The awarded amount in the awards with the word “interdisciplinary” has been as low as 1.6% during the fiscal years 1990-1994. The highest awarded amount is 24.6% of the total awarded amount in this category during 1995-1999,

which also corresponds with the period of the largest percentage of awards. The average awarded amount for the “construction AND education” awards with the word “interdisciplinary” during the study period of 1985-2024 is 11.4% .

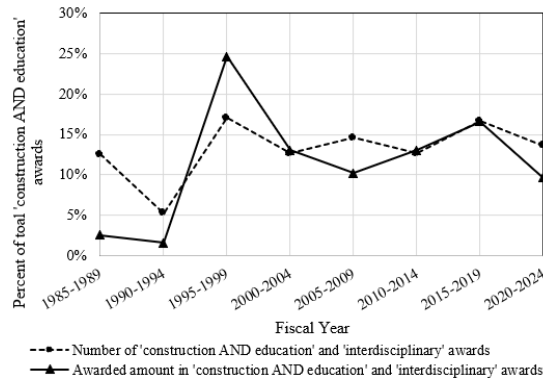


Figure 9. Awards mentioning “interdisciplinary” in “construction AND education” awards

Conclusions and discussion on limitations

The NSF awards in construction and related areas were analyzed to investigate the inclusion of an interdisciplinary approach. The award data was obtained from the pool of NSF research award data using the search word “construction” in the title and abstract of the awards for the period of October 1, 1984 (fiscal year 1985) to September 30, 2024 (fiscal year 2024). The data was then analyzed into four categories: “construction” AND “management” award, “construction” AND “trend words” award, “construction” AND “workforce” award, and “construction” AND “education” award. In each category, the award data was filtered using keywords related to that category. For example, the “construction” AND “education” category includes awards that have at least one occurrence of the words “construction” and “education” in the title or abstract. Two parameters were used to analyze the award trends: the number of unique awards and the total awarded amount for the awards. Table 2 shows the percentage of awards that include the word “interdisciplinary” either in the title or abstract of the awards in each category. The average results from the four categories show that 8.3% of unique awards used the word “interdisciplinary”, and the average awarded amount in these awards that included the word “interdisciplinary” in the title or abstract ranged from 3% to 16.5%, with an average of 10.4%.

Table 2. Summary of occurrence of the word ‘interdisciplinary research in each category

Category	Number (%)	Amount (%)
“construction” AND “management” category	8.8%	10.7%
“construction” AND trend words' award category	7.7%	16.5%
“construction” AND “workforce” category	3.7%	3.0%
“construction” AND “education” category	13.1%	11.4%

Furthermore, the analysis indicates that awards with a management focus (Figure 2) experienced sharp increases in funding during select years. Similarly, awards emphasizing interdisciplinary approaches within management and other construction-related research (Figures 3 and 5) also showed notable spikes, likely reflecting a small number of large, highly funded projects. By contrast, workforce-related awards demonstrate a more gradual and proportional increase in both the number of awards and total funding (Figure 6). Notably, within the workforce category, the term interdisciplinary did not appear until after 2005; since then, both the frequency of awards and the

associated funding incorporating this term have steadily risen, underscoring a growing recognition of the interdisciplinary nature of workforce issues in construction (Figure 7). In comparison, education-focused awards have included the term interdisciplinary since the outset of the study period, suggesting a longer-standing and more established integration of interdisciplinary approaches within construction education research (Figure 9).

The analysis has two limitations: data limitation and procedural limitation. Regarding the first limitation, this paper uses data from the NSF awards obtained using the word “construction”. As researchers in construction have access to multiple sources, both from the public and private sectors, the trend may not represent an overall picture of construction research. The second limitation is related to the process of data extraction using keywords from the pool of award data. This method of data filtering has the potential to exclude relevant data and include irrelevant data. Keywords like “construction” and “management” are not unique to the field of construction management. Although the extracted data pool was reviewed manually and with word clouds, the data pool needs further review using tools like Natural Language Processing (NLP). NLP can use trained models to identify related and unrelated research awards. Furthermore, the data pool was obtained using titles and abstracts of the awards, which may not give an accurate picture of the interdisciplinary approach of the awards. This can be further corroborated using researchers’ departments and research publications. Additionally, relying solely on the presence of the term “interdisciplinary” is an insufficient proxy, as it may exclude many relevant studies that are implicitly interdisciplinary in nature but do not explicitly use the term in their titles or abstracts. Use of NLP may solve these issues partially by identifying the context of the use of the words, but a deeper investigation using automated processes to extract information about the researchers is also required.

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