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Comparing Building Information Modeling Skills of Project Managers and BIM Managers based on Social Media Analysis

Rahimi A. Rahman[a,*], Suleiman Alsafouri[a], Pingbo Tang[a], Steven K. Ayer[a]

[a]*School of Sustainable Engineering and the Built Environment, Arizona State University, P.O. Box 870204, Tempe, AZ, 85287-0204, USA*

Abstract

Building Information Modeling (BIM) education may accelerate the process of adopting BIM in construction projects. The education community has been examining the best ways of introducing BIM into the curricula. However, individuals in different positions, such as project managers and BIM managers, may require different BIM skills in practice. Thus, understanding BIM skills could help to better formulate the education program for college students and industry professionals. The authors explored this topic by addressing two research questions: 1) What are the BIM skills possessed by individuals that increase the likelihood of having the titles "project manager" and "BIM manager"? 2) How do these skill-sets differ between project managers and BIM managers? These questions are addressed through an analysis of the LinkedIn profiles of architecture, engineering, construction, and operations (AECO) professionals. Data collection involved gathering endorsed skills, number of endorsements, current position, past positions, and years of work experiences from LinkedIn profiles of AECO professionals. This article identified BIM skills and other skills correlated with BIM skills that increase the likelihood of an individual to own the titles of "project manager" and "BIM manager." This analysis showed that the number of skills shared between project managers and BIM managers were greater than the number of unique skills possessed by either position. While the two positions shared certain skills, subsequent analysis suggested that many of those skills were correlated with different skills. This may suggest that, while there is overlap in the skills possessed between individuals in each position, the way in which they use those skillsets may differ.

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Keywords: Building Information Modeling (BIM); education; social media; project manager

* Corresponding author. Tel.: +1-480-577-3484; fax: +1-480-965-0557.
E-mail address: abinabdu@asu.edu

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1. Introduction

A Building Information Model (BIM) is a digital representation of physical and functional characteristics of a facility [1]. Adopting BIM in construction projects can be beneficial [2]. Construction projects with BIM managers might be more successful in implementing BIM [3, 4, 5]. In addition to having BIM managers, project managers need adequate BIM skills to implement BIM effectively [4, 6, 7]. Thus, these managers may require more attention than other team members in construction projects with BIM. BIM education can help employers prepare individuals with adequate BIM skills within the company, including those BIM managers and project managers [8, 9].

As the industry shifts to adopt BIM in new ways, the academic community has also begun to shift to better prepare students with the skills that will support both their career and project success. However, individuals in different positions may require different BIM skills in practice. This research explores two research questions aimed at understanding the skills needed by the more traditional project managers and the newly emerging BIM managers in industry, including: *1) What are the BIM skills possessed by individuals that increase the likelihood of having the titles "project manager" and "BIM manager"? 2) How do these skill-sets differ between project managers and BIM managers?* Answering these questions can help the industry and the education community to understand the current trend of BIM.

BIM managers are responsible for managing people, information and the model itself during projects [7, 10]. Thus, BIM managers require skills that might be similar to the skills of project managers such as teamwork and communication skills, while also requiring deeper skills in BIM such as understanding BIM standards and BIM workflow [11]. However, BIM managers have limited opportunity in their career advancements because the industry has poor awareness on the skills and expertise that a BIM manager provides [12]. As a result, some BIM managers are considering leaving their current organization to pursue consulting positions specializing in BIM [12]. Hence, comparing the skills between BIM managers and project managers can help employers understand the value that BIM managers bring, while assisting the education community to personalize BIM education.

The lack of knowledgeable practitioners hinders the industry from moving into the BIM era [13]. Finding employees capable of handling BIM technologies is a challenge [14]. Thus, the education community has been implementing BIM education into the AECO curricula to support the demand of individuals with BIM skills [15]. This includes experimenting pedagogic strategies by introducing BIM into courses [16]. The results from this article may assist the education community to personalize BIM education. Personalizing BIM education might serve the industry by providing individuals with adequate BIM skills [9] and enhancing inadequate skills by training individuals [15].

In addition to the importance of having students understand BIM technology, it may be equally or more vital for students to understand the collaborative process for using BIM to solve practical problems [17]. Moreover, the industry expects graduating students to be capable of managing BIM model and solving implementation issues [18]. Graduating students should also understand the roles and responsibilities of each individual during BIM implementation in construction projects [18]. This article compares the BIM skills in project managers and BIM managers to further assist the comprehension of the BIM skills required in graduating students.

This article explores AECO professionals' LinkedIn profiles to compare BIM skills possessed by project managers and BIM managers. The definition of both managers with a list of BIM skills are provided in Section 2.1. This is followed by detailing the steps taken to gather the data (Section 2.2) and explaining the data analyses method (Section 2.3). Section 4 presents the results and discussions, while section 5 concludes with findings.

2. Methodology

2.1. Overall approach

In order to address the research questions, the authors collected and analyzed data from LinkedIn. This type of data was chosen for this work as it is the most popular networking platform for business professionals [19]. The authors developed a systematic method using Python to collect the data on 14 and 17 November 2015.

Due to the variety of job titles that different individuals may possess on LinkedIn, a systematic naming scheme was developed to identify appropriate data for analysis. All titles with the term "project manager" were defined as project manager and all titles with the term "BIM manager" were defined as BIM manager. This includes positions with multiple titles such as "estimator/BIM manager" and positions with sub-specializations such as "architectural project manager." Job titles that were observed to have subordinating position titles, such as "assistant BIM manager" and "intern project manager", were not considered to be project managers or BIM managers.

After identifying appropriate individuals in LinkedIn based on job title, the skills possessed were also collected. Previous work identified skills that were considered to be BIM skills, including: "BIM", "Revit", "CAD", "3D", "steel detailing", "Navisworks", "submittals", "modeling", "construction drawings", "AutoCAD", "sustainable design", "metal fabrication", "renovation" and "steel" [20].

2.2. Data collection

This article used the 'search' feature of LinkedIn to identify relevant individual profiles. The search query used was "BIM." The results went through several filters, filtering the results to profiles in Phoenix, Arizona, then to profiles within the architecture & planning, construction, design and civil engineering industry. The search feature only allows one thousand results per search query. Thus, the results were further divided to one thousand results per search query by using the industry filter provided in LinkedIn.

The collected information from each profile during data collection were: 1) Name; 2) Current location; 3) Current industry; 4) Endorsed skills and number of endorsements; 5) First year of employment; 6) The earliest year of attaining the title of "Project Manager"; and 7) The earliest year having the title "BIM manager."

After collecting the data, the authors screened the data by removing duplicate profiles, profiles outside Phoenix and profiles outside the architecture & planning, construction, design or civil engineering industry. As the 'skills' feature in LinkedIn allows members to list their skills freely, skills that differed based on their text case and additional special characters were grouped together. For example, "Microstation" and "MicroStation" skills were grouped into a single skill named "Microstation." This article removed skills that were endorsed to less than 2.5% from the total number of profiles to omit the least common skills, reducing the data from potentially unrelated skills. Also, skills that were endorsed to more than 97.5% from the total number of profiles were removed, as they no longer differentiated individuals.

2.3. Data analysis

The authors performed three analyses of the collected data. The first analysis identifies the BIM skills that increase the likelihood of having the title "project manager" or "BIM manager." Binary logistic regression was used to analyze the relationship between the number of endorsements for each endorsed skill and the titles. In this analysis, the authors coded profiles with the title "project manager" as 1, and 0 otherwise during the analysis of project managers. This coding method was also used for BIM managers.

The second analysis identifies the BIM skills that reduce the number of years in attaining the title "project manager" or "BIM manager." In this analysis, the authors performed bivariate correlations to calculate the correlation coefficient between the number of endorsements of each endorsed skill and the number of years taken to attain the titles. The correlation coefficient value represents the intensity of the relationship between two variables. From the intensity of the relationship between two variables defined by Weber and Lamb [21], this article considers correlation coefficients having at least a low correlation ($\geq$0.20) as correlated.

The third analysis compared the BIM skills of project managers and BIM managers. Here, the authors performed bivariate correlations to calculate the correlation coefficients between the number of endorsements of each endorsed skill and all other skills possessed by these managers. The authors then grouped skills that are correlated with BIM skills that increase the likelihood of having both titles as shared skills. Skills that are only correlated with BIM skills that increase the likelihood of having either title were separated as "unique" skills for each of those managers.

From these analyses, this article does not attempt to interpret the context that might be conveyed by the endorsed skills because of the following two reasons: (1) No definition is provided for the skills listed by LinkedIn; and (2) The skills can be interpreted differently between endorsers.

3. Results and discussions

This section describes the results for the following three analyses: 1) Identifying the BIM skills that increase the likelihood of having the title "project manager" or "BIM manager"; 2) Comparing the skills that are correlated with these BIM skills; and 3) Grouping those skills into shared skills and unique skills in either position.

Table 1 shows the information for the collected data. The authors accessed 1,784 profiles (90%) from the 1,995 profiles available during data collection. After screening the profiles, 1,543 profiles remained. Of the 2,787 total number of endorsed skills for this population, no skills were possessed by more than 97.5% of profiles, but 2,654 skills were possessed by less than 2.5% of the profiles. After removing skills that were endorsed to less than 2.5% of the profiles, 133 skills remained. These remaining 133 skills were compared to the BIM skills in project managers and BIM managers.

Table 1. Summary of the data collected

Characteristics	Number of observations	Characteristics	Number of observations	Min	Max	Average
Profiles	1,543	All skills	2,787			
Industry		Endorsed to less than 2.5%	2,654			
Architecture & planning	683	Endorsed between 2.5% and 97.5%	133			
Construction	655	Endorsed to more than 97.5%	0			
Design	127					
Civil Engineering	78	Skills within 95% confidence interval	133			
Title : Project manager (PM)	431	Endorsements	205,219	0	362	1.20
PM	257					
PM with multiple titles	108	Years				
PM with sub-specializations	66	Of experience	1,530	0	56	15.96
Title : BIM manager (BM)	39	Taken to attain PM title	431	0	40	5.01
BM	12	Taken to attain BM title	39	0	29	8.70
BM with multiple titles	21					
BM with sub-specializations	6					

3.1. Identifying the BIM skills in project managers and BIM managers

Table 2 shows the logistic regression predicting likelihood of having the title "project manager" or "BIM manager" for each additional endorsement of BIM skills. "Steel detailing", "construction drawings" and "modeling" resulted in a 9.1%, 5.6% and 4.3% increase in the likelihood of having the title "project manager" per additional endorsement, respectively. These increment in the likelihood were higher than other BIM skills. "Steel detailing", "3D" and "Revit" increased the likelihood of having the title "BIM manager" by 17.5%, 8.4% and 5.0% per additional endorsement, respectively. Again, these increment in the likelihood were higher than other BIM skills. The results indicate "steel detailing" as the most likely BIM skill to increase the likelihood of having both the "project manager" and "BIM manager" titles. It can be concluded that "steel detailing" is one of the only BIM skills that increased the chances of having both positions. Additionally, "construction drawings" and "modeling" increase the chances of becoming a project manager, and "3D" and "Revit" increase the chances of becoming a BIM manager. The difference in BIM skills may illustrate the different responsibilities of project managers and BIM managers.

The results indicate that BIM skills increase or decrease the likelihood of having the title "project manager" or "BIM manager" at a similar odds ratio between 0.741 and 1.175. Though, there is an exception for "steel" of BIM managers with an odds ratio at 0.039. From the data, all BIM skills have endorsements in both project managers and BIM managers besides "steel" of BIM managers. There might be two possible reasons for this situation to occur.

First, BIM managers may not use "steel" to perform their responsibility. Second, the number of BIM managers are less (n=39) compared to project managers (n=431).

Table 2 also shows the correlation coefficients between BIM skills and the decrease in years of attaining the title "project manager" or "BIM manager." BIM skills have either positive/negative slight correlation with the decrease in years of attaining either title. This excludes "renovation", which has a negative low correlation with the decrease in years of attaining the title "BIM manager." The results indicate that BIM skills do not necessarily accelerate the promotion process to either project manager or BIM manager positions.

Table 2. Logistic regression predicting likelihood of having the title and correlation results on the decrease in years of attaining the title "project manager" or "BIM manager" for BIM skills

Analysis	Logistic regression								Correlation
Skill/Variables	β[a]	S.E.[b]	Wald[c]	df[d]	Sig.[e]	Odds ratio Exp(β)[f]	95% C.I. for odds ratio[g]		Pearson Correlation
							Lower	Upper	
Project manager									
BIM	-0.015	0.011	1.845	1	0.174	0.985	0.964	1.007	0.002
3D	-0.051	0.039	1.730	1	0.188	0.951	0.881	1.025	0.013
AutoCAD	-0.031	0.015	4.024	1	0.045	0.970	0.941	0.999	-0.030
CAD	0.004	0.017	0.043	1	0.836	1.004	0.971	1.037	-0.017
Construction drawings	0.055	0.018	9.589	1	**0.002**	**1.056**	1.020	1.093	0.017
Metal Fabrication	0.001	0.054	0.000	1	0.990	1.001	0.901	1.111	-0.078
Modeling	0.043	0.053	0.642	1	0.423	**1.043**	0.940	1.158	-0.009
Navisworks	-0.046	0.028	2.791	1	0.095	0.955	0.905	1.008	0.052
Renovation	-0.033	0.016	3.925	1	0.048	0.968	0.937	1.000	0.028
Revit	0.008	0.012	0.494	1	0.482	1.008	0.985	1.032	-0.032
Steel	-0.020	0.030	0.430	1	0.512	0.980	0.924	1.040	-0.055
Steel detailing	0.087	0.031	8.145	1	0.004	**1.091**	1.028	1.159	0.000
Submittals	0.016	0.010	2.628	1	0.105	1.016	0.997	1.036	0.027
Sustainable design	0.000	0.013	0.000	1	1.000	1.000	0.975	1.025	-0.012
BIM manager									
BIM	0.031	0.014	4.972	1	**0.026**	1.031	1.004	1.059	0.006
3D	0.081	0.128	0.398	1	0.528	**1.084**	0.843	1.394	-0.046
AutoCAD	-0.042	0.047	0.783	1	0.376	0.959	0.875	1.052	0.035
CAD	-0.008	0.048	0.025	1	0.875	0.992	0.903	1.090	0.048
Construction drawings	0.020	0.053	0.149	1	0.700	1.021	0.920	1.132	0.027
Metal Fabrication	-0.300	0.200	2.253	1	0.133	0.741	0.501	1.096	0.036
Modeling	-0.137	0.184	0.559	1	0.455	0.872	0.608	1.249	-0.075
Navisworks	0.004	0.078	0.003	1	0.955	1.004	0.861	1.171	-0.075
Renovation	0.017	0.085	0.041	1	0.840	1.017	0.861	1.201	-0.385
Revit	0.049	0.015	10.73	1	**0.001**	**1.050**	1.020	1.081	0.020
Steel	-3.235	209.474	0.000	1	0.988	**0.039**	0.000	-	-
Steel detailing	0.161	0.101	2.546	1	0.111	**1.175**	0.964	1.432	-0.139
Submittals	-0.018	0.031	0.339	1	0.560	0.982	0.924	1.044	-0.024
Sustainable design	-0.056	0.049	1.306	1	0.253	0.946	0.859	1.041	-0.096

[a] β = logistic coefficient; [b] S.E. = standard error of estimate; [c] Wald = Wald chi-square values; [d] df = degree of freedom; [e] Sig. = significance; [f] Odds ratio Exp(β) = exponentiated coefficient; [g] 95.% C.I. for odds ratio = 95% confidence interval for odds ratio.

3.2. Comparing the BIM skills in project managers and BIM managers

Table 3 shows the correlation coefficients between the identified BIM skills that increase the likelihood of a given job title and all other skills found in the title. For example, the correlation coefficients between "steel detailing", "construction drawings" and "modeling" and all other skills in project managers are shown for project managers. Correlation coefficients with "*" represent those that are statistically significant at $\alpha = 0.05$. While bolded correlation coefficients represent having at least one positive low correlation (≥0.20) and statistically significant at $\alpha = 0.05$. From the results, this analysis identified the skills that are significantly correlated with those BIM skills that increased the likelihood of having the title "project manager" and "BIM manager."

"Steel detailing" in project managers is correlated with "drawing", "metal fabrication", "Navisworks", "new business development", "steel" and "steel structures." "Steel detailing" in BIM managers is correlated with "3D studio max", "architectural drawings", "AutoCAD", "BIM", "comprehensive planning", "construction drawings", "design research", "drawing", "facilities management", "high rise", "LEED", "MEP", "Navisworks", "piping", "Revit", "SketchUp", "space planning" and "submittals." This illustrates that the same BIM skills for individuals with different positions are correlated with different skills. In other words, project managers and BIM managers may use the same BIM skills for different purposes.

Table 3. Correlation coefficients between the identified BIM skills that increase the likelihood of a given job title and all other skills found in the title.

Title	Project manager			BIM manager		
Skills/ BIM skills that increases the likelihood of having the title	Steel detailing	Construction drawings	Modeling	Steel detailing	3D	Revit
3D	0.004	0.004	**0.897***	0.240	1	**0.445***
3D modeling	-0.003	0.014	0.060	0.173	**0.536***	0.017
3D studio max	0.024	0.060	0.004	**0.589***	**0.327***	**0.340***
Architectural design	-0.018	**0.382***	-0.028	0.269	0.260	**0.605***
Architectural drawings	0.102*	**0.431***	-0.006	**0.652***	-0.152	**0.389***
AutoCAD	0.115*	**0.315***	0.023	**0.391***	**0.601***	**0.531***
BIM	0.190*	**0.246***	**0.563***	**0.387***	**0.561***	**0.819***
CAD	0.116*	**0.254***	0.054	0.258	**0.664***	**0.614***
Comprehensive planning	0.000	**0.240***	-0.025	**0.448***	0.117	**0.606***
Construction drawings	0.155*	1	-0.029	**0.601***	**0.500***	**0.783***
Construction safety	-0.066	-0.090	-0.035	0.207	**0.462***	-0.110
Design research	0.040	**0.410***	-0.031	**0.524***	0.205	**0.807***
Drawing	**0.221***	0.167*	0.050	**0.854***	-0.090	**0.450***
Facilities management	-0.049	0.013	-0.024	**0.353***	**0.354***	**0.413***
High rise	-0.018	-0.016	-0.017	**0.338***	**0.363***	**0.426***
Interior design	0.036	0.159*	-0.011	0.105	**0.405***	**0.567***
LEED	0.033	**0.221***	-0.031	**0.752***	0.023	**0.535***
MEP	-0.030	-0.019	-0.006	**0.351***	**0.356***	**0.415***
Metal fabrication	**0.639***	0.064	0.083	-0.055	-0.079	-0.110
MicroStation	-0.002	-0.008	0.014	0.254	**0.351***	**0.437***
Mixed-use	0.020	**0.340***	-0.029	0.09	**0.399***	**0.600***
Navisworks	**0.240***	0.124*	**0.207***	**0.770***	**0.458***	**0.457***
New business development	**0.411***	0.029	-0.009	n/a	n/a	n/a
Piping	-0.029	-0.060	-0.014	**0.375***	**0.592***	0.182
Revit	0.092	**0.245***	**0.234***	**0.618***	**0.445***	1
SketchUp	0.033	0.152*	0.009	**0.391***	0.307	**0.614***
Space planning	0.016	**0.344***	-0.028	**0.406***	0.062	**0.342***
Steel	**0.613***	0.055	0.051	n/a	n/a	n/a
Steel detailing	1	0.155*	0.069	1	0.240	**0.618***
Steel structures	**0.562***	0.022	0.069	n/a	n/a	n/a
Submittals	0.069	**0.460***	0.054	**0.625***	**0.437***	**0.777***
Sustainable design	0.013	**0.329***	-0.027	0.308	0.311	**0.659***
Urban design	0.050	0.185*	-0.017	0.089	**0.404***	**0.568***

Bolded represents having at least a positive low correlation (≥0.20) and statistically significant at $\alpha = 0.05$.
* Represents statistically significant at $\alpha = 0.05$

3.3. Shared skills and unique skills between projects managers and BIM managers

Table 4 shows the shared skills and unique skills between project managers and BIM managers based on the BIM skills and their correlated skills identified in previous sections. Eighteen skills are shared together by project managers and BIM managers. Project managers have five unique skills, while BIM managers have eleven unique skills. This illustrates that project managers and BIM managers have more shared skills than unique skills between them. There are a number of possible reasons for this similarity between the positions. Potentially, there is not yet a consistent set of BIM-related responsibilities for different project participants on different projects. In other words, it

is possible that on some projects when a dedicated BIM manager is present, the act of managing steel detailing is performed by that individual, whereas on other projects where a dedicated BIM manager is not staffed, a project manager may assume this responsibility. Another potential explanation for this similarity could be related to when these skills were endorsed. It is possible that project managers had received similar skill endorsements to BIM managers from earlier in their careers when they were doing tasks that were more closely aligned to BIM management. LinkedIn does not provide information on the time frame of those endorsements. Hence, this article could not validate whether the skills were endorsed as a project manager or before becoming a project manager.

While many of the correlated skills are shared between BIM managers and project managers, there are also a number of unique skills that are only correlated with one of the positions. Project managers have five unique skills, while BIM managers have eleven unique skills that are correlated with their promotion to their respective positions. The differences in the unique skill-sets between project managers and BIM managers indicate some unique responsibilities between them. This may illustrate the values that the BIM managers can provide into construction projects, where there are certain skills are not possessed by project managers. Thus, employers might need to reconsider the importance of BIM managers in construction projects, and to be cautious in combining the responsibilities of BIM managers into project managers.

Table 4. Shared and unique skills between project managers and BIM managers from BIM skills and their correlated skills that increases the likelihood of having the title "project manager" or "BIM manager."

Project manager	**Project manager and BIM manager**		**BIM manager**	
Metal fabrication	3D	Drawing	3D modeling	MEP
Modeling	Architectural design	LEED	3D studio max	MicroStation
New business development	Architectural drawings	Mixed-use	Construction safety	Piping
Steel	AutoCAD	Navisworks	Facilities management	Sketchup
Steel structures	BIM	Revit	High rise	Urban design
	CAD	Space planning	Interior design	
	Comprehensive planning	Steel detailing		
	Construction drawings	Submittals		
	Design research	Sustainable design		

From the results, BIM skills that increase the likelihood in having the title "project manager" the most are "steel detailing", "construction drawings" and "modeling." While "steel detailing", "3D" and "Revit" are the BIM skills that increase the highest likelihood of having the title "BIM manager." The results also identified skills that are significantly correlated with these BIM skills. Also, the results identified the shared and unique skills between project managers and BIM managers. The results illustrate that the same BIM skills in individuals with different positions are correlated with different skills. Project managers and BIM managers have more shared skills than unique skills from the BIM skills and their correlated skills of having the titles. While several skills do not indicate a statistically significant relationship at $\alpha = 0.05$, it supports the need for future work to determine necessary skills for success in both career paths through a larger sample size and additional data sources.

The results also illustrate that there might be a "hub skill" between several skills. The hub skills can be identified as a core skill that has greater number of relationships with the related skills. In this sense, the hub and the related skills together can form a group of skills called cluster. Learning hub skills may help to broaden the career advancement of individuals. Future research should analyze those skills from LinkedIn that may illustrate the relationships in different hubs between project managers and BIM managers.

Although this article offers insights in comparing the BIM skills in project managers and BIM managers, it does have some limitations. The authors only analyzed profiles from Phoenix, AZ and a small percentage of profiles (10%) were excluded from this article due to limited access to private profiles. This article also did not analyze the different types of project managers and BIM managers. Furthermore, the data collected are unverified data since the authors collected the data through social media. However, the data collection method used in this article can be an alternative source of data besides data from self-reporting methods.

4. Conclusions

This article analyzes AECO professional's LinkedIn profiles to compare the BIM skills possessed by project managers and BIM managers. The purpose of this comparison is to provide insights about designing better BIM education programs for college education and life-long learning programs. More specifically, the authors identified BIM skills and their correlated skills that increase the likelihood of having the title "project manager" and "BIM manager." From those skills, the number of shared skills between these titles is greater than the number of the unique skills possessed by either position. While the two positions shared certain skills, subsequent analysis suggested that many of those skills were correlated with different skills. This may suggest that, while there is overlap in the skills possessed between individuals in each position, the way those skillsets are used may differ.

The findings of this article may potentially indicate some of the skills that contribute to success in different industry positions. The identified skills may also guide the design of personalized BIM education. Future work will employ additional research methods to identify BIM skills needed for success in different project roles, which will assist in the design of future BIM curricula.

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