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Educational Theory-Integrated Construction Industry Training: State-of-the-Art Review

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Workforce training is needed throughout the construction industry to create and maintain competent workers; unfortunately, most construction training and education research focuses on university student education. Integrating education science theory into construction training has the potential to improve industry training, but the status of this integration has not been well articulated. To address this gap, this article undertakes a state-of-the-art review of education theory–integrated construction training for current industry professionals. To measure the extent of educational theory integration, this article identifies and summarizes studies that meet inclusion criteria, identifies the frequency of occurrence of Bloom's Taxonomy verbs as a measure of student learning outcomes, and identifies and compares commonly used words within the identified construction training literature and foundational educational theory literature. This article presents a systematic review of published construction workforce training studies that have incorporated educational theory in the design and implementation of the training. The results reveal that, of the 15 construction training studies that met the inclusion criteria, two-thirds (2/3) focused on worker safety and only three studies (20%) targeted managers or designers. Fewer than 35% of terms that were identified as frequently used terms in the published construction training studies were categorized as educational. The results of this study provide a baseline of education theory–integrated construction training research, from which gaps and best practices can be identified and implemented to improve construction industry training.

Keywords: workforce training, educational theories, Bloom's Taxonomy, andragogy, content analysis

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INTRODUCTION

Job training plays a vital role in the creation and maintenance of a capable workforce in the construction industry (Waddoups, 2014). Training is effective when learning is promoted (Ahmad et al., 2012), which is optimized through theories developed within the field of education science (Ormrod, 2008) that focus on how learners obtain, process, and retain information. Despite the well-known shortage of construction industry training (Rahim et al., 2016; Silva et al., 2018; Akomah et al., 2020), there is a surprising lack of recommendations for holistic improvement of construction training across the industry. For example, the suggestion by Tatum (2018) that graduate programs may be a potential remedy to increase skills within the construction industry fails to address the ubiquitous lack of training (Kazaz et al., 2008) for the construction workforce.

Learning is the perpetual change in conduct generated by experience (Bass and Vaughan, 1968). Throughout human history, interest in learning has been evident, becoming amplified in the 20th century when several proven learning theories emerged (Rücker, 2017). Kaufman (2003) suggested that when learning theories are employed in teaching methods, both knowledge and skills increase. The incorporation of educational theory into workforce training has been noted in industries such as information technology (e.g., Gaikwad and Bharathi, 2018), computer science (e.g., Antonis et al., 2011), ecology (e.g., Parkinson et al., 2003), and law enforcement (e.g., Michael, 2003), to name a few. A growing body of research has focused on education of construction management and civil engineering undergraduate and graduate students (e.g., Jensen and Fischer, 2006; Harfield et al., 2007; Kamardeen, 2014; Cho et al., 2015; Lee et al., 2016; Holt et al., 2018; Talley and Torres, 2018; Poon, 2019; Torres et al., 2019; Kim and Irizarry, 2020); however, few studies have focused on construction industry workplace training (Detsimas et al., 2016). The proven outcomes associated with formalized educational theory warrant a comprehensive review of the current state of construction workforce training that integrates educational theory in its design.

To improve our understanding of the state of construction training for current construction professionals, serving as a starting point to understand how to overcome training-related challenges in the industry, this article provides a review of educational theory-integrated construction industry training and undertakes the following research questions:

- To what extent is educational theory integrated in construction training for current industry professionals? Which educational theories are most often integrated?
- Which construction training subject(s) most commonly include(s) educational theory for current industry professionals?
- To what extent does the construction training literature discuss student learning outcomes, quantified as the frequency of occurrence of Bloom's Taxonomy verbs?
- What is the distribution of Bloom's Taxonomy levels in the construction training literature?
- To what extent does frequent terminology used in the construction training literature match that of foundational education theory literature?

To answer these questions, a state-of-the-art review of education theory–integrated construction training for current industry professionals is undertaken. This review begins with identifying inclusion criteria to capture the literature that is relevant to this study and studies that meet these criteria are described through case review. Using autonomous counting, Bloom's Taxonomy verb categories are used to enumerate the occurrences of each Bloom's Taxonomy verb, sort terms found in the studies, and enumerate the occurrences of each verb to extract patterns across each of the studies. Autonomous counting was also used to determine the most frequently used terms across the identified studies and across the foundational educational theories referenced in the identified studies. Using the results of this analysis, comparisons are made between the terms found in the studies and the terms found in the foundational educational literature.

The contribution of this research is a systematic review of published construction workforce training studies that have incorporated educational theory in the design and implementation of the training. This study measures the extent of educational theory integration in construction industry training programs by analyzing completed research that has incorporated educational theory in training design. The results of this study provide a snapshot of the current state of professional construction training and are intended to serve as a starting point for improvement of future industry training. The intended audience of this article is construction education and training researchers, professionals, organizations, and groups.

MATERIALS AND METHODS

The methodology undertaken in this study includes the following steps: 1) relevant studies are identified through implementation of inclusion criteria, 2) each identified study is described through a case review, 3) the occurrence frequency of Bloom's Taxonomy verbs within each study is quantified as a measure of student learning outcomes, 4) frequently used terminology across all studies is identified and quantified, 5) frequently used terminology within foundational educational theory literature is identified and quantified, and 6) frequently used terminology found in steps 4 and 5 is compared.

Study Selection

The study undertaken in this article implements a structured literature review to collect data on education theory–integrated construction training for current industry professionals. This approach, called Preferred Items for Systematic Review Recommendations (PRISMA), was implemented by Moher et al. (2009). The objective is to understand the extent that construction training programs that have embedded established educational theory in their design or implementation of the training. The main search keywords were "construction industry," "education theory," and "training." The main research engines were Google Scholar and the Grok Knowledge Base, and they were used to identify relevant research outputs. The following inclusion criteria were established to identify recent, relevant peer-reviewed construction training studies published after 2005 for investigation in this study:

1. The training focuses on the current construction industry workforce, including construction workers (W), project managers (M), and designers (D).
2. The training incorporated educational theory in the creation or implementation of the training.

Using the keywords mentioned above, a search of literature was conducted resulting in 475 research outputs then increased to

TABLE 1 | Bloom's Taxonomy categories and associated verbs (Anderson and Krathwohl 2001).

Remember	Understand	Apply	Analyze	Evaluate	Create
Choose	Arrange	Apply	Analyze	Appraise	Arrange
Define	Cite	Chart	Calculate	Assess	Assemble
Enumerate	Classify	Collect	Categorize	Choose	Collect
Identify	Comprehend	Compute	Compare	Compare	Compose
Indicate	Describe	Construct	Contrast	Contrast	Construct
Know	Discuss	Demonstrate	Criticize	Criticize	Create
Label	Explain	Document	Debate	Critique	Design
List	Explore	Dramatize	Detect	Decide	Formulate
Match	Express	Employ	Determine	Defend	Generate
Memorize	Extrapolate	Give examples	Diagram	Estimate	Integrate
Name	Generalize	Interpret	Differentiate	Evaluate	Organize
Omit	Identify	Investigate	Disassemble	Grade	Perform
Recall	Indicate	Operate	Distinguish	Judge	Plan
Record	Infer	Practice	Examine	Justify	Prepare
Relate	Interpret	Predict	Experiment	Measure	Produce
Repeat	Judge	Schedule	Inspect	Rate	Propose
Reproduce	Locate	Shop	Inventory	Reframe	Set up
Select	Manage	Show	Justify	Revise	Synthesize
State	Match	Sketch	Question	Score	
Underline	Paraphrase	Transfer	Relate	Select	
	Recognize	Translate	Separate	Value	
	Report	Use	Solve	Weigh	
	Represent		Subdivide		
	Restate		Test		
	Review				
	Show				
	Suggest				
	Summarize				
	Tell				
	Trace				
	Translate				

483 through identification of other sources referenced in the initial search results. After removing duplicates, applying the inclusion criteria, and additional quality measures, 15 publications were selected for the review, indicating limited research conducted in this area. The selection process is illustrated in the PRISMA flow chart in **Figure 1**.

The following information was recorded from the relevant publications that met the inclusion criteria: location (i.e., country) where the study took place, educational theory employed, training subject, and the audience (W, M, and D). Adult learning or adult education was often referenced as the educational theory employed, which was recoded as "andragogy," defined as the methodology for teaching adult learners (Knowles, 1980). To identify different approaches, a summary table was constructed comparing the cases that met the inclusion criteria.

Training Case Review

The review begins by summarizing the objectives, methods, and results in a case review. The case review is created to provide context of the studies.

Bloom's Taxonomy Verb Frequency

Bloom's Taxonomy is a six-level hierarchical model that classifies cognitive objectives developed by Bloom (1956) and revised by Anderson and Krathwohl (2001). Bloom's Taxonomy categories and associated verbs used to identify and quantify training learning objectives are provided in **Table 1**.

Autonomous counting, used to generate number of occurrences that stand on their own merit (Hannah and Lautsch, 2011), was used to enumerate the occurrences of each Bloom's Taxonomy verb to extract patterns across each of the studies, a method which Horner et al. (2011) implemented to evaluate the potential effectiveness of lesson plans designed for college courses. NVivo 12, a qualitative data analysis software application, was used to identify the frequency of occurrence of each verb by level. To identify common gaps, the frequency of all verbs within each level is reported, along with the most frequent verbs within each level.

While autonomous counting is effective in generating data that produces interpretable results by analyzing the outcome of the counting methodology, potential for error in the results exists. Due to the nature of the terms that are counted, it is possible that certain terms that are not used to represent the training program are used throughout the articles that have undergone review. Due to the large quantity of text reviewed, NVivo 12 was used to accomplish this goal of counting and it is not possible for software to make these distinctions. However, occurrences of terms used that are categorized by Bloom's Taxonomy that do not represent the training program are limited and do not affect the outcome of this study. This method was used to provide a metric by which to characterize the language on a general level to determine the

TABLE 2 | Identified educational theory-integrated construction industry training studies.

Study number and reference	Country	Educational theory	Subject	Audience
(1) Akanmu et al. (2020)	United States	Digital game-based learning	Ergonomic safety	W
(2) Begum et al. (2009)	Malaysia	Ajzen's theory	Waste management	W
(3) Bena et al. (2009)	Italy	Andragogy	Safety	W
(4) Bhandari and Hallowell (2017)	United States	Andragogy	Safety and risk perception	W
(5) Bressiani and Roman (2017)	Brazil	Andragogy	Masonry Brick Laying	W
(6) Choudhry (2014)	China	Behaviorism	Safety	W
(7) Douglas-Lenders et al. (2017)	Australia	Self-efficacy	Leadership training for project managers	M
(8) Eggerth et al. (2018)	United States	Andragogy	Safety	W
(9) Evia (2011)	United States	The Kirkpatrick model	Safety	W
(10) Forst et al. (2013)	United States	Andragogy	Safety	W
(11) Goulding et al. (2012)	United Kingdom	Digital game-based learning	Offsite production	W, M, D
(12) Mehany et al. (2019)	United States	Long-term retention	Confined space training	W
(13) Lin et al. (2018)	United States	Andragogy	Safety	W
(14) Lingard et al. (2015)	Australia	Visual pedagogy	Construction health and safety	W
(15) Wall and Ahmed (2008)	Ireland	Blended learning	Project management	M

educational area of focus for construction industry training with educational theory embedment.

Training Content Analysis

Autonomous counting was used to determine the most frequently used terms across all identified studies, excluding those categorized as Bloom's Taxonomy verbs to identify common gaps. NVivo 12 was used to automatically determine frequently mentioned text or words that occur across the selected studies. These terms were segregated depending on if they were related to education, general construction terminology, or the training topical area.

Foundational Educational Theory Content Analysis

Content analysis was also performed to evaluate frequently mentioned ideas or concepts that occur across the foundational articles of the educational theories used in the identified training studies. Using NVivo 12, text or words mentioned across the foundational education theory articles were automatically selected.

Content Analysis Comparison

Frequent terminology found within the construction training studies was compared with frequent terminology found within the foundational educational theory publications to identify differences and similarities.

RESULTS

Study Selection

Fifteen studies describing education theory–integrated construction industry training met the inclusion criteria, listed in alphabetical order in **Table 2**. All studies referenced educational theories in their implementation or used educational theories as the basis of design. Digital game-based learning, Ajzen's theory, andragogy, behaviorism, self-efficacy, the Kirkpatrick model, visual pedagogy, long-term retention, and blended learning were identified as the educational theories implemented. Andragogy was the theory referenced most frequently, used in six of the 15 training studies (40%). Ten of the studies (67%) focused on safety as the main training subject. The training for three studies (20%) was intended for managers or designers, while training for 13 studies (87%) was intended for workers.

Training Case Review

This section presents a brief review for each of the 15 studies presented in **Table 2** to provide additional context to the scope of the current literature.

- Akanmu et al. (2020) implemented a virtual reality (VR) training focused on reducing construction worker ergonomic risks. Study participants were fit with wearable sensors to record worker posture while typical construction tasks were simulated. The educational theory implemented in this study was virtual reality training fueled by incorporating a game engine or gamification.
- Following training on the subject of waste management and waste disposal methods to part of the study group, Begum et al. (2009) administered a survey to Malaysian contractors to measure attitudes and behaviors toward waste management. Ajzen's theory was cited as the motivation for conducting the training, claiming that intention is the prerequisite to planned behavior.
- Bena et al. (2009) offered 4-h safety training modules for construction workers on a high-speed railway line project in Italy, consisting of one basic module and four job specific modules presented in a classroom environment.
- Bhandari and Hallowell (2017) conducted multimedia training that integrated adult learning principles to demonstrate the cause and effect of hand injuries during construction situations, focusing on injuries caused by falling objects and pinch points. The training simulated

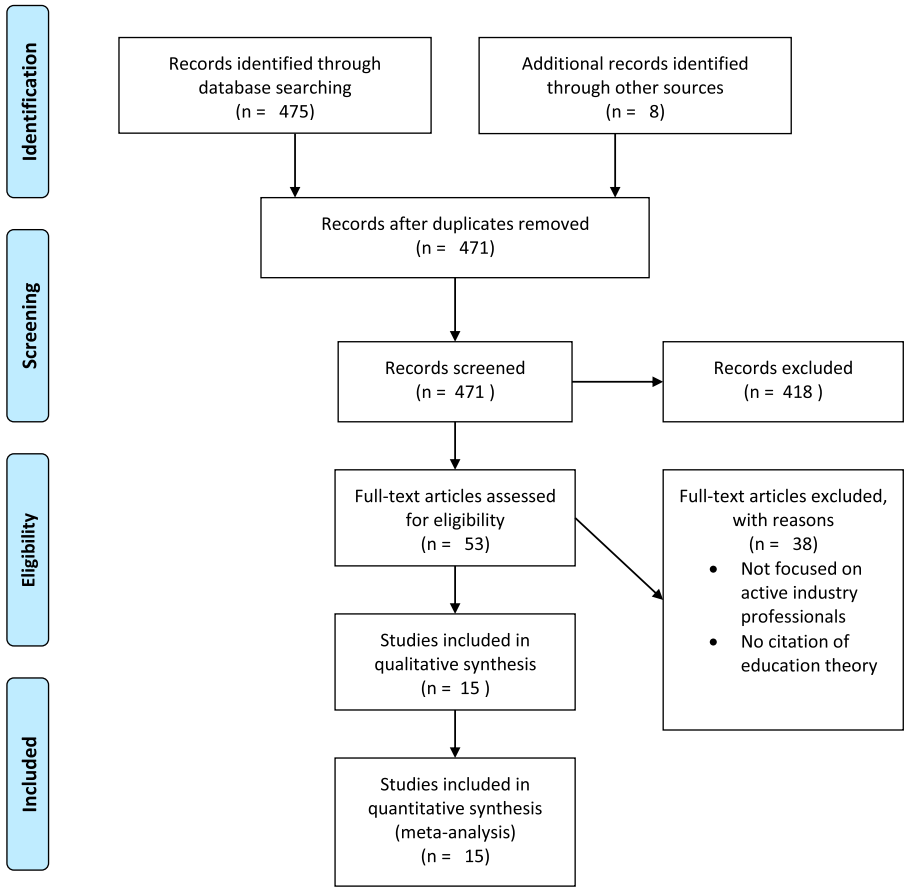

FIGURE 1 | PRISMA Flow Diagram of Studies Screened for Construction Training.

injuries that occur on jobsites with realistic prosthetic hands.

- Bressiani and Roman (2017) developed a training program for masons using andragogy. The training was provided to two groups of masons from structural masonry projects.
- Choudhry (2014) presented a safety training program for construction workers and safety observers based on behavior-based safety or behaviorism.
- Douglas-Lenders et al. (2017) presented a two-day program where participants were trained in a traditional classroom environment and through simulation to enhance leadership, communication, and safety skills.
- Eggerth et al. (2018) describe eight safety training "toolbox talks," which are brief instructional sessions on a jobsite or in a contractor's office. The materials were developed by adult education specialists.
- Evia (2011) describes computer-based safety training for construction workers. The Kirkpatrick model was used in the design and evaluation of the training program.
- Forst et al. (2013) describe a safety training for construction workers in seven cities across the United States. Adult learning principles were used to train worker leaders to deliver a modified version of the OSHA curriculum to their peers.
- Goulding et al. (2012) present the findings of an offsite production virtual reality training prototype where participants navigate new working conditions and unforeseen problems. This training platform was developed based on the theory of game-based training, which is linked to the theory of motivation, claiming the motivation is a key factor in effective learning.
- Mehany et al. (2019) present a confined space training program for construction workers. Tool-box talks were used as the main training delivery method for this study, where long-term retention theory was used for its design.
- Lin et al. (2018) used computer-based three-dimensional visualization, designed by adult education subject matter experts, to train construction workers on safety and fall fatalities.
- Lingard et al. (2015) implemented participatory video-based training to identify safety concerns on a construction jobsite. Workers viewed recordings of common safety concerns and shared protocols for mitigating safety risks. Visual pedagogy was used as there is evidence that a

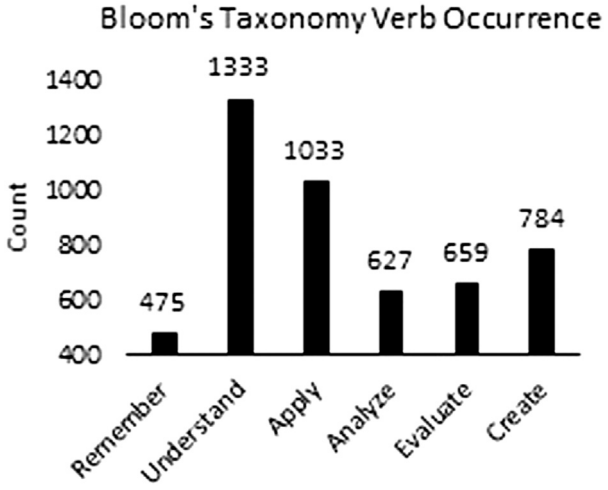

FIGURE 2 | Bloom's Taxonomy Verb Frequency by Level for Reviewed Articles (n = 15).

preference exists for visual rather than verbal learning (Mayer and Massa 2003).

- Wall and Ahmed (2008) explore training for project managers using construction management computerized tools. A blended learning platform was used; which refers to an educational method that combines delivery methods, including face-to-face classroom with asynchronous and/or synchronous online learning (Wu et al., 2010).

Bloom's Taxonomy Frequency

The occurrence of Bloom's Taxonomy verbs found across the fifteen studies reviewed is enumerated by the level (**Figure 2**).

Further analysis of the Bloom's Taxonomy verb categories reveals the five most frequently used verbs in each level, the frequency with which they were used, and the relative frequency of the verb usage within its respective taxonomy level. The results of this analysis are presented completely in the Appendix and summarized in **Table 3**. Note that in **Table 3**, the total percentages do not add to 100%, as other verbs were used in each level. The full results can be calculated using the data provided in the Appendix. Approximately 60–73% of the Bloom's Taxonomy verbs used in the studies are found in the five most frequently used verbs. The verb category used most frequently is "understand," accumulating more than 27% of the Bloom's Taxonomy verbs in the identified studies.

Training Content Analysis

The results of the training content analysis are presented in **Table 4**, truncated to terms appearing 40 times or more across the studies, an average of slightly more than 2.5 times article. This number was selected to capture the most important words across all the articles while ignoring inadvertently used words. The study numbers across the top of **Table 4** correspond with the order of studies in **Table 2**. Of the 23 terms with 40 or more occurrences across the 15 studies, eight were related to training or education, 13 were general to the construction industry, and two were related to safety. The terms in **Table 4** are listed alphabetically, with the number of occurrences in each study and total occurrences across the 15 studies. For purposes of this analysis, the most frequent education-related terminologies in the order of frequency (high to low) are: training, learning, behavior, study, knowledge, experience, simulation, and group. Studies 2, 4, 11, 14, and 15, each have more than 50 occurrences of these eight most common terms while studies six and eight have fewer than 20 occurrences.

TABLE 3 | Absolute and relative frequencies of most frequently used Bloom's Taxonomy verbs.

Bloom's level	Verb	Count	Per cent of total
Remember	State	107	22.5%
	Select	85	17.9%
	Indicate	73	15.4%
	Record	35	7.4%
	Know	31	6.5%
	Total	331	69.7%
Understand	Manage	471	35.3%
	Show	127	9.5%
	Report	120	9.0%
	Describe	90	6.8%
	Review	83	6.2%
	Total	891	66.8%
Apply	Practice	186	18.0%
	Show	127	12.3%
	Compute	124	12.0%
	Operate	111	10.7%
	Give examples	80	7.7%
	Total	628	60.7%
Analyze	Experiment	185	29.5%
	Test	138	22.0%
	Question	54	8.6%
	Analyze	41	6.5%
	Criticize	41	6.5%
	Total	459	73.1%
Evaluate	Evaluate	136	20.6%
	Assess	96	14.6%
	Score	92	14.0%
	Select	85	12.9%
	Rate	73	11.1%
	Total	482	73.2%
Create	Perform	226	28.8%
	Set up	105	13.4%
	Plan	63	8.0%
	Propose	63	8.0%
	Organize	50	6.4%
	Total	507	64.6%

Foundational Educational Theory Content Analysis

Nine foundational educational articles were identified for the theories integrated in the construction literature. Content analysis by autonomous counting was conducted with NVivo 12 to evaluate the article contents to determine recurring themes that occur across the literature. **Table 5** presents the results of the content analysis in the alphabetical order for Ajzen's theory (Ajzen, 1985), self-efficacy (Bandura, 1977), visual pedagogy (Fransecky and Debes, 1972), blended learning (Garrison and Kanuka, 2004), the Kirkpatrick model (Kirkpatrick, 1959),

TABLE 4 | Frequency of terminology in evaluated studies by term type.

Type	Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Training/Education	Behavior	1	2	2	-	1	-	18	-	-	-	-	-	-	-	37	61
	Experience	3	7	4	3	5	-	1	1	1	1	6	2	2	7	7	50
	Group	-	3	20	3	2	-	1	-	8	2	2	3	1	1	-	46
	Knowledge	3	12	12	3	2	5	-	1	5	1	5	2	1	4	1	57
	Learning	23	15	-	10	7	4	-	1	1	1	16	19	8	20	-	125
	Simulation	1	4	-	1	12	-	-	-	-	-	18	8	-	2	-	46
	Study	3	11	3	1	3	5	4	1	2	2	9	1	3	3	7	58
	Training	12	33	7	55	12	5	4	8	17	19	16	-	9	16	3	216
	Total																659
General	Construction	15	17	9	21	9	10	11	8	18	9	3	19	9	13	34	205
	Contractor	-	-	-	1	-	1	2	1	-	2	-	-	-	-	36	43
	Data	4	17	2	1	1	2	4	1	-	2	3	-	1	6	2	46
	Environment	9	6	-	4	3	4	3	-	-	-	7	2	1	17	-	56
	Industry	2	7	6	1	5	2	3	-	1	-	1	3	4	3	9	47
	Management	-	2	1	-	2	7	12	-	-	2	5	16	-	4	28	79
	Materials	4	1	1	10	1	1	3	1	9	1	-	-	2	1	15	50
	Methods	5	15	-	2	2	4	5	3	1	2	4	1	3	2	9	58
	Project	-	1	-	-	-	1	5	1	6	1	1	6	-	14	12	48
	Research	2	23	-	-	2	2	7	2	5	-	6	3	4	2	2	60
	Site	4	3	-	1	-	2	10	2	3	4	2	1	-	7	3	42
	Workers	19	9	5	33	14	20	5	18	18	21	7	5	8	13	1	196
	Total																930
Topic area	Injury	4	5	2	3	17	1	6	11	-	10	-	-	-	-	-	59
	Safety	-	31	24	18	10	5	34	4	13	8	-	-	-	2	-	149
	Waste	-	-	-	-	-	-	-	-	-	-	-	-	-	-	69	69
	Total																277
Total		114	224	98	171	110	81	138	64	108	88	111	91	56	137	275	1866

TABLE 5 | Frequency of terminology in foundational education literature.

	Ajzen (1985)	Bandura (1977)	Fransecky and Debes (1972)	Garrison and Kanuka (2004)	Kirkpatrick (1959)	Knowles (1980)	Prensky (2003)	Shiffrin and Atkinson (1969)	Watson (1913)	Total
Activities	1	3	8	1	1	8	-	-	2	24
Behavior	26	15	3	-	-	-	-	2	11	57
Change	-	11	-	6	1	3	1	3	-	25
Effects	3	9	-	4	1	-	3	19	2	41
Experience	1	6	16	4	-	9	1	-	-	37
Information	1	3	4	4	2	-	1	35	-	50
Language	-	-	22	-	-	-	1	-	3	26
Learning	-	2	3	16	1	18	4	8	1	53
Memory	-	1	1	-	-	-	-	42	1	45
Model	1	9	3	1	-	2	-	11	-	27
Performance	2	23	1	-	1	-	-	4	-	31
Process	1	3	2	2	-	9	1	22	4	44
Response	5	11	1	-	-	-	-	26	3	46
Search	-	-	-	-	-	-	-	28	-	28
Subject	14	4	2	1	4	2	3	1	1	32
Tasks	-	10	1	1	-	8	-	13	-	33
Visual Literacy	-	-	23	-	-	-	1	-	-	24
Total	55	110	90	40	11	59	16	214	28	623

andragogy (Knowles, 1980), digital game-based learning (Prensky, 2003), long-term retention (Shiffrin and Atkinson, 1969), and behaviorism (Watson, 1913). The same reporting threshold implemented for the previous content analysis was used for these articles, resulting in terms appearing at least 24 times across the nine articles being reported.

Content Analysis Comparison

Approximately, one-third of the terms in **Table 4** consists of terms related to education, while all terms in **Table 5** are associated with the field of education. While the reviewed studies are within the realm of the construction industry, they do focus on training. As such, one may expect a similar emphasis

on education-related terminology. Instead, the absolute frequency of education-related words in the construction studies (659; 44 terms per article) is close to that in the foundational literature (623; 69 terms per article).

The terms learning, behavior, and experience appear in both **Tables 4**, **5**. Further analysis reveals that in **Table 4** across all studies. Of the 1866 commonly occurring terms in **Table 4**, the occurrence frequency for "learning" is 125 (6.7% of the total), for "behavior" is 61 (3.3%), and for "experience" is 50 (2.7%). This is contrasted with **Table 5**, where the occurrence frequency for "learning" is 53 (8.5% of the total), for "behavior" is 57 (9.1%), and for "experience" is 37 (5.9%).

DISCUSSION

Study Selection and Training Case Review

The majority of studies that met the inclusion criteria were on the subject of safety, indicating a lack of education theory–embedded training for construction means and methods. Only three studies focused on managers or designers, while the remainder of the studies focused on workers. Seven articles were published in the 4-year period 2017-2020, while eight articles were published in the preceding nine years (2008-2016), indicating an increasing focus on education theory–integrated construction industry training research. Six of the fifteen studies (40%) integrated andragogy in the training. Andragogy is the study of facilitating adult learning, in contrast to pedagogy, the study of facilitating child learning (Knowles, 1980). The heavy utilization of this theory across the studies is potentially due to the fact that construction industry professionals are adults and using an educational theory specifically tailored to that group is an obvious choice when designing educational theory-integrated training programs. Seven of the fifteen studies were conducted in the United States, with two in Australia, and one each in Malaysia, Italy, Brazil, China, United Kingdom, and Ireland.

Bloom's Taxonomy Frequency

Bloom's Taxonomy is designed on a hierarchical scale, meaning that each level is built on the assumption that each higher level subsumes the lower levels that precede it. This implies that learners at higher levels should meet objectives pertaining to the higher levels of the taxonomy such as the analysis, evaluation, or creation levels. From **Table 1**, the hierarchical levels of Bloom's Taxonomy begin with "understand" or the ability to recall and ultimately move toward creation, which is the ability to put components together to form a whole. Based on this theory, as learners reach higher levels, terms from higher categories should be used more frequently, while terms from lower levels should be used less frequently.

Across the fifteen studies, mixed results are observed in the Bloom's Taxonomy verb frequency, where are from the greatest to least frequency: understand (891), apply (628), create (507), evaluate (482), analyze (459), and remember (331). Both "understand" and "apply" are lower order skills, while the higher order terms have less frequent usage, in no discernible order, and finally, terms associated with "remember" are used least frequently. One can assume that the target audience of a training or educational experience should have mastery of lower order skills. This leads to the use of the higher order skills such as analyze, evaluate, and create. However, no consistent pattern in student learning objectives is observed, indicating that assumptions of the target audience must vary across the studies or that Bloom's Taxonomy objectives were not explicitly considered. From this evaluation, one cannot determine whether the trainings analyzed were designed assuming participants had little to no exposure to the subject of training or if they had moderate exposure and were ready to move onto higher order skills.

Training and Foundational Educational Theory Content Analysis and Comparison

The content analysis revealed that relatively few common terms across the studies were explicitly linked to education. This is surprising given that the underlying topic of the identified articles is training in the construction industry. For foundational articles of the educational or learning theories cited by the studies, all of the most frequent terms are connected to the field of education, indicating a marked difference between the frequency of the words in **Tables 4**, **5**. This disparity is further evidenced by the difference in relative frequency of occurrences of the terms learning, behavior, and experience described in the results section.

Observations

Observations were made regarding the studies that met the inclusion criteria. Overall, two-thirds of the studies focus on safety, while 100% of the studies from the United States reflect safety training. This indicates that the primary focus of training for current construction industry professionals is safety and that little focus is given to other subjects of construction. This observation begs certain questions. Why the topic of safety is disproportionately represented in the literature above other topics? Although safety is ubiquitous, are safety professionals more likely to integrate educational theory into training and publish their findings in the literature? This observation is rather remarkable and warrants further investigation, especially in light of the shortage of skilled construction professionals discussed in the Introduction.

CONCLUSION

This article provides a state-of-the-art review of educational theory-integrated construction industry training. Inclusion criteria were established to identify relevant peer-reviewed articles published after 2005 for investigation. After identifying 15 relevant studies, case review was conducted to summarize the educational theories employed, training subjects, and target audience. The frequency of Bloom's Taxonomy verbs were enumerated and summed across the identified studies. Content analysis was conducted on the identified studies, and the foundational literature for the educational theories identified

by those studies to identify the most frequently used terms, which were compared for similarities and differences. The findings of this study are as follows:

- Fifteen studies were found that met the inclusion criteria; of these, two-thirds (2/3) focused on worker safety.
- Andragogy was the most often integrated educational theory, used in 40% of the studies.
- Three studies that met the inclusion criteria (20%) focused on managers or designers, while 80% of the studies focused on workers.
- More than 27% of the Bloom's Taxonomy verbs in the identified studies are associated with the second lowest level, "understand."
- Less than 35% of the most frequent terminology in the identified studies was categorized as educational.
- All frequently used terms in the foundational educational theory literature were considered educational.
- Common educational terminology between the studies and foundational educational theory analyzed appear at higher rates in the foundational literature.

Overall, this study found that not many construction industry training programs have been published in the archival literature. It is surprising that so little attention has been paid to scholarly research to education theory–integrated construction training programs, given the impact that construction has worldwide. Certainly, training program exists through certain industry organizations; however, information about these types of programs was not apparent in the literature. Further, as workers, managers, and designers progress in their careers and technology evolves, there is a need for continuing education to keep these individuals abreast of recent changes. This appears to be an opportunity to address this lack of training in the construction, and this article can serve as a starting point for those wishing to develop. Given the tremendous need for quality construction training worldwide, this study serves as a starting point in the improvement of further industry training by providing a comprehensive review of documented educational theory–integrated construction training.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, and further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

HJ conducted the literature review, collected and analyzed, and developed the initial text. CF provided original ideas and advice on the overall project methodology and edited the text. CB proposed the research methodology and provided the conceptual design of this research. IN, CP, and YZ edited the text and provided regular feedback and guidance.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fbuil.2021.635978/full#supplementary-material

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