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Recommended Citation

Kaskutas, Vicki; Dale, Ann Marie; Lipscomb, Hester; Gaal, John; Fuchs, Mark; Evanoff, Bradley A.; and Program Instructor Team, Carpenters' Joint Apprenticeship, "Changes in fall prevention training for apprentice carpenters based on a comprehensive needs assessment". *Journal of Safety Research*, 41, 3, 221-227. 2010.

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ELSEVIER

Contents lists available at ScienceDirect

Journal of Safety Research

journal homepage: www.elsevier.com/locate/jsr

www.nsc.org

Changes in fall prevention training for apprentice carpenters based on a comprehensive needs assessment[☆]

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ARTICLE INFO

Article history:

Received 5 October 2009

Received in revised form 15 January 2010

Accepted 25 January 2010

Available online 22 April 2010

Keywords:

safety and health
construction safety
injury prevention
training
apprenticeship
Construction

ABSTRACT

Problem: Falls from heights in residential construction are common, especially among inexperienced workers. **Methods:** We conducted a comprehensive needs assessment to determine gaps in the school-based apprentice carpenters' fall prevention training. A team of carpenter instructors and researchers revised the fall prevention training to fill these gaps. Apprentice evaluation and feedback guided ongoing curricular improvements. **Results:** Most apprentice carpenters performed work tasks at heights prior to training and fall protection techniques were not commonly used at residential construction sites. Priorities of the revised school-based training included safe ladder habits, truss setting, scaffold use, guarding floor openings, and using personal fall arrest systems. New apprentices were targeted to ensure training prior to exposure at the workplace. We used adult learning principles to emphasize hands-on experiences. A framed portion of a residential construction site was fabricated to practice fall protection behaviors in a realistic setting. The revised curriculum has been delivered consistently and apprentice feedback has been very favorable. **Conclusions:** Integration of needs assessment results was invaluable in revising the school-based carpenters apprentice fall prevention curriculum. Working closely with the instructors to tailor learning experiences has provided preliminary positive results. **Impact on Industry:** The fall safety of the residential construction industry continues to lag behind commercial construction and industrial settings. The National Occupational Research Agenda includes a Strategic Goal to strengthen and extend the reach of quality training and education in the construction industry via mechanisms such as construction safety and health training needs assessments. This study demonstrates how a structured process can be used to identify and remedy gaps and improve training effectiveness. We encourage others to take steps to assess and increase the impact of training efforts directed at all residential construction professionals; including both union and non-union workers. The implications are even greater in the non-union sector where most U.S. residential work is done.

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1. Introduction and background

Construction is one of the nation's largest industries, employing about 8 million workers in 2007 (U.S. Bureau of Labor Statistics [BLS],

2010). Approximately 56% of construction work is performed in residential settings; including 13% residential building, 8% residential finishing, and 31% specialty trades (BLS, 2010). In 2007, falls from heights accounted for 43% of the fatalities in residential building, which is higher than in the overall construction sector (BLS, 2007). Residential construction workers are frequently exposed to working conditions that place them at risk of falling from heights, which can be especially hazardous to inexperienced workers.

Residential construction workers face unique hazards and safety considerations. The primary consideration in home construction planning is the aesthetic goal of the homeowner, not the safety of the construction workers. Steeply pitched roofs challenge workers sheathing and shingling the roof, and large vaulted ceilings limit workers' ability to use stepladders to reach work surfaces. Work crews are generally dispersed and small, therefore, workers perform a wide

[☆] Grant sponsor: Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health through the Center for Construction Research and Training, Grant #U54OH008307. National Institutes of Health/National Center for Research Resources through Washington University Institute of Clinical and Translational Sciences, Grant #1 UL1 RR024992-01.

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variety of tasks. The work environment and associated safety hazards change quickly, making it difficult to use environmental controls at home construction sites. Personal fall arrest systems can protect workers during some phases of the construction process, however, securing anchorage sites while setting roof trusses poses unique challenges. Residential construction in the United States has suffered in the recent economic downturn, creating increased anxiety about profit margins in an already fast-paced sector of the industry. These factors can foster practices and timelines that favor work speed over worker safety.

Residential construction workers must be skilled and vigilant in order to safely perform work tasks at heights. Apprenticeship programs are expected to help inexperienced workers develop the skills necessary to work in this hazardous environment. These programs require both formal classroom instruction and on-the-job training under the mentorship of journeymen during the three- to four-year training program (U.S. Department of Labor, 2009). Apprenticeship programs must conform to specific standards in order to obtain and maintain accreditation, although methods of delivery and proficiency testing vary among apprenticeship programs. The National Guidelines for Apprenticeship Standards describe the standard carpentry skills training and on-the-job experience (5,200–8,000 hours) required to develop skilled and productive workers for the unionized carpentry trade (United Brotherhood of Carpenters and Joiners of America, 2005).

Since the required formal educational attainment of construction workers is lower than required for employees in other industries (The Center to Protect Workers' Rights [CPWR], 2003), it is especially important for apprenticeship programs to design their training to meet the specific learning needs of their population. As a unique group of learners, construction workers do not enjoy "book learning." Albers and colleagues (1997) found that apprentice carpenters consistently preferred participatory teaching methods over traditional classroom instruction, with only 43% reporting lectures as useful. Adult learners want timely, well-organized training by experts that builds on their skills, is practical, and can easily be applied to their situation (Fogarty & Pete, 2004). This paper describes the process implemented to redesign the fall prevention training of apprentice carpenters in order to better prepare them to safely work at heights at residential construction sites. This process began with a needs assessment to identify the limitations of the existing training. This multilevel needs assessment included data on apprentice carpenters' knowledge and beliefs, as well as observation of safety behaviors at home-building sites. Based upon data from the needs assessment, we prioritized training needs and designed learning experiences to address existing gaps in the training experiences of apprentice carpenters. The revised training model is being tested through a variety of process and outcome measures.

2. Materials and methods

2.1. Setting and research team

Our project was a joint venture between the St. Louis Carpenters' Joint Apprenticeship Program (CJAP) and occupational health researchers at Washington University in St. Louis and Duke University. The CJAP is supported by the Carpenters' District Council of Greater St. Louis (CDC) and homebuilding contractors who employ union carpenter members. The team included university researchers, leaders of the carpenters' union, construction contractors, and the faculty of the apprenticeship training program.

Apprentice carpenters attend an initial one-week training session at CJAP prior to beginning work for a construction company. They return for additional two-week training courses at CJAP every six months throughout their four-year apprenticeship program, for a total of nine courses. CJAP instructors are journeymen carpenters with

construction experience and an interest in teaching carpentry skills and safety; instructors have or are pursuing a bachelor's degree in workforce training, education, or a related area. The CJAP Board, made up of leadership from the CDC and representatives of construction contractors, meets regularly to approve the training curriculum and monitor the apprenticeship program.

2.2. Needs assessment

The overall goal of the needs assessment was to assess the current state of fall prevention training received by apprentice carpenters through school-based training and on-the-job experiences, measure apprentices' knowledge, attitudes, beliefs, and behaviors, and to use this information to identify gaps in fall prevention training. We employed a variety of data collection methods, allowing input from apprentice carpenters through focus groups, surveys, and direct observation of their work on residential jobsites, as well as from the apprenticeship instructors. Each element is described below.

2.2.1. Focus groups

We conducted focus groups with apprentices ($n = 36$) representing all levels of training in order to understand factors influencing the effectiveness of their fall prevention training. Topics explored included common fall hazards encountered, usual worksite practices, timing and adequacy of school-based training and on-the-job mentoring, barriers to using fall prevention practices at residential sites, and recommendations to improve training. We have previously described the focus group methodology and results (Lipscomb, Dale, Kaskutas, Sherman-Voellinger, & Evanoff, 2008).

2.2.2. Apprentice surveys

A 72-item survey was completed by a large ($n = 1,025$) and representative sample of apprentices during regularly scheduled training at CJAP. This survey measured fall prevention knowledge, risk perception ratings, training prior to task performance, preferred teaching methods, confidence in fall prevention abilities, reported crew behaviors, and workplace safety climate, as well as demographic construction-specific data and history of recent falls from height.

2.2.3. Worksite audit

An observational audit, entitled the St. Louis Audit of Fall Risks (SAFR; Kaskutas et al., 2009), was performed by trained journeymen carpenters on the research team at residential worksites ($n = 197$) to measure the fall prevention behaviors of residential work crews. This audit of 52 dichotomously scored items covered nine domains: general safety climate and housekeeping, floor joist and sub-floor installation, walking surfaces and edges, wall openings, truss setting, roof sheathing, ladders, scaffolds, and personal fall arrest equipment. A brief interview of each carpenter logged carpentry experience, frequency of on-the-job safety and fall prevention training, familiarity with the contractor's fall prevention plan, and availability of personal fall arrest equipment at the worksite. The audit, interview, and manual describing administration procedures are available at the Electronic Library of Construction Safety and Health website (Kaskutas, Evanoff, Dale, & Lipscomb, 2008), developed by the Center for Construction Research and Training. Details of the audit development process and pilot results have been previously described (Kaskutas, Dale, Lipscomb, & Evanoff, 2008), as well as the audit results at 197 residential worksites (Kaskutas et al., 2009).

2.2.4. Documentation of existing curriculum

Instructors for all of the apprenticeship training courses logged existing fall prevention training delivered in their courses, including a description of the content, training method, and time allotted.

2.3. Identifying gaps in the curriculum

A core group of CJAP instructors worked closely with the research team to analyze results from the focus groups, surveys, and worksite audits and compare to the existing fall prevention training. We constructed a matrix to compare the frequency of fall experience and training, and the scores on the knowledge, risk perceptions, confidence, and behaviors scales across the various phases of the home construction process (floor joist and sub-floor installation, walking surfaces and edges, wall openings, truss setting, roof sheathing, ladders, scaffolds, and personal fall arrest equipment). The team identified the phases of construction and specific items with the poorest performing areas as targets for the revised curriculum.

2.4. Designing the new curriculum

The instructor team designed curricular changes to address each of the gaps identified; these became the training priorities of the new curriculum. Specific objectives for each priority described the level of cognition expected on Bloom's taxonomy (knowledge, comprehension, application, analysis, synthesis, or evaluation), which was driven by the nature of the gap that had been identified. The team chose educational methods and teaching techniques that matched the preferences identified by the apprentices and were supported by adult learning theory. We identified equipment and supplies needed to support the educational methods and training priorities. In order to ensure consistency of curriculum delivery, detailed lesson plans were written to describe training sequence, equipment, tools, and methods. Feedback from all instructors at the program was solicited for some of the training modules. Portions of the training were piloted and adjustments made in order to best meet the gaps identified and deliver the necessary training in a feasible manner within the limits of the curricular schedule.

2.5. Curriculum delivery and monitoring

After instructor training was complete, the new fall prevention training was initiated on April 15, 2007. Instructors followed the lesson plans and modified them appropriately to best meet the students' needs. We logged the number of revised training sessions delivered and the number of apprentices participating in the revised courses. Curriculum delivery was closely monitored to ensure consistency and quality. In order to evaluate the feasibility and student response to the revised curriculum, process evaluation was performed at three levels: (a) achievement of the learning objectives for each class was logged and monitored, (b) process evaluations were completed by 80–150 apprentices in each of the courses that involved revised training in order to obtain immediate feedback about the effectiveness of training, and (c) focus groups were held with apprentices participating in at least one course to discuss training effectiveness and methods to improve training. After reviewing this feedback, the instructor team adjusted the training when it was apparent that it would improve student performance in the target areas. The team continued to monitor the process evaluation results and adjust the training based on feedback in an iterative process, logging all changes to monitor response to the revisions.

3. Results

3.1. Needs assessment

3.1.1. Existing training

Apprentices participating in focus groups reported that they worked on elevated surfaces early in their careers and usually prior

to training, noting that journeymen at the worksite often assumed that they know how to do tasks that they do not know how to do. Furthermore, less than one third (<33%) of the apprentices reported that they received school-based training in home-building tasks that involve working at heights, such as: roof sheathing, working near unprotected openings, working on ladders, and setting floor joists, trusses, and outside walls. Apprentices reported that the school-based training they received was safety-focused, but that the methods taught in school did not correspond to methods actually employed on their worksites.

Consistent with these reports, the review of the existing curriculum found that the primary fall prevention teaching performed with brand new apprentices was to show a 20-minute fall prevention videotape. Apprentices were not required to demonstrate competency in fall prevention behaviors or knowledge. After this brief orientation to fall prevention, apprentices work at construction sites for 5–6 months before returning for additional school-based training. Fall prevention training was addressed in five of the other eight courses over the 4-year apprenticeship including an orientation to personal fall arrest systems and scaffold erection. The focus of the fall prevention training was mainly on commercial applications, with residential methods covered only briefly. Apprentices participating in focus groups suggested more training early in the apprenticeship so that inexperienced workers could function more competently. Interestingly, they felt that this could decrease some of the dissatisfaction that led to program dropouts.

Training typically occurred in the classroom setting, except for ladder jack and pump jack scaffolding training, which was performed in the shop with the actual equipment. The primary teaching method used was for the instructor to read the federal safety regulation out loud from the OSHA 1926 book while the apprentices highlighted the sentences the instructor read, a common method for OSHA training. However, our surveys showed that this was the least preferred teaching method; apprentices strongly preferred hands-on practice through real-world experiences and disliked classroom activities and lectures. This was confirmed by apprentices in focus groups, who clearly articulated their preferences for demonstration through hands-on training and reality-based training, which prepared them for what really happens in the field (Lipscomb et al., 2008).

3.1.2. Apprentice fall experience

Of the 1,025 apprentices surveyed, 16% reported falling from a height at work in the past year and 51% knew someone who had fallen at work. The majority of these falls occurred from ladders (30%), trusses/top plate/joists (18%), floor openings (17%), and scaffolds (12%). The average distance fallen was 3 meters, with a range from 0.6 to 9 meters. Loss of balance, slip/trip, and weather conditions were the most common contributing factors. Fortunately most of these falls did not result in serious injury, lost or restricted time, medical care, or prescription medication. Many apprentices participating in our focus groups noted dangerous work is frequently assigned to new apprentices as a "rite of passage" to "break" them.

3.1.3. Knowledge and attitudes

The average knowledge score on the eight questions on the survey about fall prevention standards was 58%, supporting the focus group findings that apprentices do not know how to safely perform many work tasks. The knowledge score ranged from 35% for the correct size of a hole that must be covered, to 80% for the height that fall prevention is required. Most apprentices believed the size of a floor opening that required covering was 12" (30 cm) or larger in diameter, rather than correct diameter of 2" (4.4 cm). Ladders were perceived as the lowest risk task on the survey (mean of 3.2 on a 1–10 scale); steep roofs were perceived as posing the most risk (7.2 on a 1–10 scale). Apprentices in focus groups reported they must "get over their fear"

so they can perform these risky tasks since they cannot tell journeymen that they are unwilling to do something they feel is unsafe.

3.1.4. Self-reported and observed fall prevention behaviors

Apprentices rated how often their crew used fall protection methods on the job, and our auditors visited worksites to measure fall prevention compliance on-the-job. Apprentices' surveyed reported many unsafe crew behaviors such as: always or often walking floor joists (36%), using an unopened stepladder leaned against a wall (39%), and standing on the top of exterior walls (40%). Working on the top of walls was also described as a common practice by apprentices participating in focus groups. Despite OSHA's residential guidelines' requirement for controlled access zones to be monitored by a designated worker or foreman, 21% of apprentices reported that unprotected floor openings were never monitored. Personal Fall Arrest Systems (PFAS) were reported as not used at the worksite by 48% of the apprentices and used often or always by only 13% of all apprentices surveyed. This was confirmed by the worksite audits, with PFAS in use at only 5% of the worksites visited.

We identified a high prevalence of fall hazards at the 197 residential sites audited; the overall mean safe behavior observation rate was 60% (Kaskutas et al., 2009). Truss setting met the safety criteria least consistently (28%), followed by work at unprotected floor openings and edges (43%), and floor joist and subfloor installation (48%). Marking and monitoring of unguarded floor openings was rare (18% and 2%, respectively). The first two trusses were never set from ladders or hanging scaffolding at any of the homes audited, and layout work in preparation for trusses was performed safely only 17% of the time. The brief interviews demonstrated that apprentice carpenters were less familiar with their employers' fall prevention plan than experienced workers (79% apprentices vs. 90% journeymen). Despite the widespread use of unsafe work practices reported above, 90% of apprentices surveyed agreed that safety is a priority with management.

3.2. Gaps identified in the existing curriculum

Upon review of the existing curriculum, it was apparent that inexperienced apprentices were not adequately prepared in fall protection by the existing apprenticeship training program and that there was a need for a unified approach to fall prevention training. In order to identify the specific gaps of the existing curriculum, the core group of CJAP instructors and the research team compared the knowledge, risk perception, beliefs, and behavior results from the focus groups, surveys, and worksite audits for the phases of home construction. This team targeted phases of the construction process with consistently poor scores, as well as deficit areas identified in the needs assessment. Specific gaps identified in the existing curriculum are described in Fig. 1. For example, stepladders accounted for most of the apprentices' falls and were used by nearly all apprentices surveyed; however, stepladders were rated as the least risky task performed, training was rare, and unsafe ladder behaviors were commonly reported and observed by auditors. Similarly, apprentices lacked knowledge about walking surfaces and edges, unprotected floor openings were rarely marked and monitored, and guardrails were often not in place; therefore a gap in training for walking surfaces and edges existed. Despite accounting for the second highest number of falls and being rated as the riskiest work task, truss setting was rarely performed safely at worksites (27% of the time), apprentices lacked truss setting knowledge, and training was low in this area. Several findings intrigued the team, including the high apprentice safety climate ratings despite a high prevalence of unsafe fall prevention and the high degree of apprentice confidence in their ability to prevent a fall. Although these areas were not identified as gaps in the curriculum, they were interpreted as opportunities for intervention.

3.3. New curriculum

3.3.1. New training content

Fig. 1 also describes the training priorities and training methods. A total of 39 objectives were integrated into four of the nine apprenticeship training courses, for a total of 17 hours of fall prevention training. Most of the training was designed for the inexperienced apprentices, with 2 hours performed with brand new apprentices, 5.5 hours with apprentices with 6 months of experience, 1 hour with apprentices with 1 year in the union, and 6.5 hours with apprentices in their final year of training. This represents a significant increase in time devoted to fall prevention; for example new apprentices receive six times more training in the revised curriculum as compared to the baseline curriculum. Detailed lesson plans describe the learning activities and teaching methods for each of the targeted topic areas. We set four objectives and devoted 35 minutes in the pre-apprentice course in order to raise awareness about falls from heights, increase their feelings of susceptibility, and help apprentices understand that tasks that do not appear risky account for most of the falls.

Ladder training was one of the priorities of the revised curriculum. Despite widespread use of ladders and the well-documented associated risk in this population, apprentices did not appreciate the fall hazards posed by ladders. Unsafe ladder setting and climbing behaviors were common. A total of eight objectives (110 minutes total) were integrated into three of the courses to address ladder risks, ladder setting, and ladder climbing behaviors. When ladders were being taught in a new context, such as in reference to scaffolds, ladder setting and climbing was reviewed in the new context. The level of cognition expected of each ladder objective matched the gap identified, hence a change in belief was the goal when attempting to increase risk perception of ladders, knowledge change was the goal of knowing when and how to stabilize the top of an extension ladder, and behavior was the outcome expected of ladder climbing objectives.

Since both knowledge and behaviors were lacking in the area of unprotected walking surfaces and edges, the objectives focused on these levels of cognition. The definition, requirements, and proper use of controlled access zones was explained and demonstrated to the apprentices, as were guardrail construction and installation, and methods to cover holes. Six objectives (45 minutes) in three of the courses were integrated into the revised curriculum.

Truss setting was also identified as a priority area, and eight objectives were set to increase apprentice awareness of the OSHA standards regarding truss setting and demonstrate safe alternatives to walking the exterior walls to perform truss setting. The majority of time spent on truss setting (4.5 hours) is in a truss and rigging specific course with upper term apprentices, however 40 minutes is spent early in the curriculum on this topic. It was not feasible to have apprentices set the trusses on the tops of the house walls due to inadequate roof height in the training facility; therefore we settled on a lower level of cognition according to Bloom's taxonomy and used alternative methods described below. Scaffolds, personal fall arrest systems, and roof sheathing were the other priority areas of training.

3.3.2. New training methods

Adult learning principles were integrated into the training, including hands-on practice, problem-solving activities, increasing feelings of susceptibility through story-telling, and role-playing to empower apprentices to confront experienced carpenters about unsafe work methods. For example, in order to change risk perceptions associated with ladder climbing, apprentices arranged pictures of various work tasks from lowest to highest risk of falling. This task forced apprentices to discuss their risk perceptions in a small group and troubleshoot methods to decrease the risks. When knowledge was the expected outcome, classroom lecture may be an appropriate method of information transfer; however, when behavior

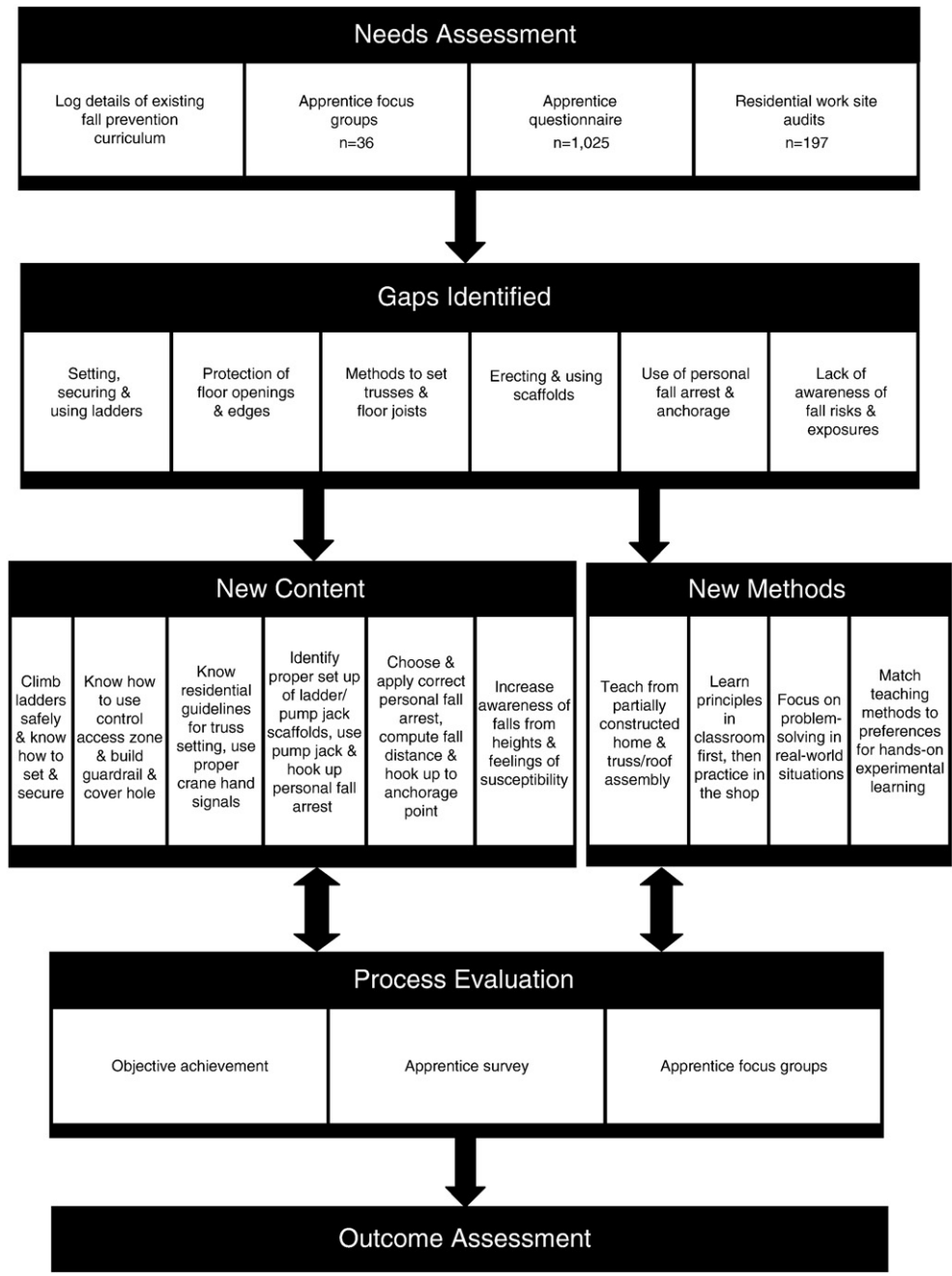


Fig. 1. Curriculum revision process.

was the goal, actual performance was expected in the shop setting. Experiential exercises in the shop setting were included as much as possible in order to match the apprentices' preference for 'hands-on,' 'real-world' training. Since the shop area is through a door off of each classroom at the CJAP, apprentices can learn the knowledge in the classroom setting and then immediately apply it and practice safe behaviors in the shop setting. Since the ceiling height in the shop limited our ability to demonstrate how to set trusses and work on roofs, we had to identify alternative methods for these tasks that would still allow them to see and experience the task. The team identified and obtained equipment and supplies used at residential worksites, including commercially available equipment to prevent falls. Several vendors donated equipment to the CJAP.

A mock home was constructed in the shop to allow apprentices to observe and practice using fall prevention methods and equipment in a context that mimics a residential construction site (Fig. 2). This full-

scale home includes many of the fall hazards present in a home construction site, including floor openings, leading edges, exposed floor joists, window openings, holes, top plates, and trusses. The instructors demonstrated how to protect these openings with hole covers, guardrails, warning lines, and talked through how to install the floor joists and roof trusses from ladders and hanging scaffold systems. In a later course, apprentices stand on the ground while trusses are set nearby on the ground in order to experience trusses 'flying' overhead and practice using hand signals to communicate with the crane operator. A truss/roof assembly next to the mock home allows apprentices to observe and experience working from roof brackets, slide guards, and anchorage devices for personal fall arrest systems while safely positioned near the floor. Apprentices choose, inspect, apply, and utilize personal fall arrest systems. They learn how to assemble pump jack systems and ladder jack systems, practice climbing these scaffolds, and hook up their personal fall arrest



Fig. 2. Mock home demonstrates fall safety hazards and fall protection methods.

systems to vertical life lines. At least one apprentice per class steps off of a scaffold to experience suspension from a life line by the harness, explaining to classmates the uncomfortable sensations associated with this. Lectures and movies continue to be used, however, they are always followed up with practice in the shop to apply what was discussed. We continue to provide apprentices with the OSHA regulation book and orient them to the fall prevention sections, however, highlighting the book is rarely used.

3.4. Evaluation of revised training

The team measured the consistency of the revised training by monitoring achievement of learning objectives each time a course was taught; the effectiveness of the curriculum was assessed through post-course apprentice survey and focus groups. Objective achievement was continually monitored and adjustments in teaching plans made to ensure the curriculum was consistently delivered. The major variance in delivering the revised curriculum has occurred around holidays, when shortened work weeks gave inadequate time to cover all of the material. Objective achievement rates were analyzed after eight months of teaching the revised curriculum. Since achievement of objectives was lower than expected in the six-month class, the lesson plans were revised to a more realistic level for the time allotted. Since revision of the objectives, 78 revised training courses have been delivered to 974 total participants. The rate of objective achievement was 97% to 99% for all sessions besides the new apprentice course, which was 80%; the overall achievement rate was 89%. We are exploring methods to increase objective achievement in the new apprentice course.

We have also surveyed approximately 83 to 176 apprentices per training class at the completion of each revised training class for apprentice feedback. Apprentices ($n = 150$) participating in the new apprentice training reported that the residential prop was an effective training tool (96%) and 81% stated that they will change their stepladder work habits as a result of training. Six-month apprentices ($n = 176$) stated that they feel that they will use the safety behaviors learned in class (83%) and will be able to compute free fall distance for personal fall arrest devices (85%). Last year apprentices ($n = 83$) stated that they will change their scaffold behaviors (83%) and they can use proper rigging methods (92%). We also ran two focus groups with new apprentices to generate feedback regarding the training

materials and methods. The training appeared to impact many of the apprentices as evidenced by feedback such as, "I will use these safety tactics daily, I had no knowledge of them before," and "I learned a lot about my own interpretation of risks...risk perception is different than it seems at first."

4. Discussion and conclusions

A comprehensive needs assessment that combined quantitative and qualitative methods was a useful method for identifying gaps in existing apprenticeship fall prevention training and preferred learning methods of apprentices. Importantly, we assessed real-world safety behaviors at residential worksites employing apprentice carpenters, in addition to utilizing self-reported measures. Documentation of the existing training allowed us to understand the breadth and depth of the current training and served as a starting point for revisions. Use of various assessment methods at multiple levels (including small group discussions, survey of a large sample of apprentices, and worksite observations using a standardized instrument) ensured that the needs assessment results were reliable and representative of the population of apprentices we were targeting. Actual observation of worksite behaviors was a powerful method for understanding the effectiveness of the existing safety training as well as for providing "real world" examples of what apprentices face on jobsites. By comparing the results across these different measures, we increased our confidence that we were able to identify important gaps in knowledge, attitudes, and behaviors. Understanding the learning preferences of our apprentice population helped the team design learning objectives and teaching methods to match the apprentices' learning styles and meet the identified training needs.

This project involved collaboration among university researchers, leaders of the carpenters' union, construction contractors, and faculty of an apprenticeship training program. Our backgrounds and strengths as well as work schedules and styles were quite different, and we continue to become accustomed to working together. However, we are linked by a common purpose and commitment that continues to sustain our efforts. Identification of the content areas and concerns that we needed to address in this collaborative effort including underestimation of the risks of common behaviors such as ladder use, lack of knowledge of methods to work at unprotected openings, and improper truss setting methods was made easy by the

use of a gap analysis matrix. However, the solutions were less apparent. By seeking input from learners and working collaboratively, the team was able to design a fall prevention curriculum that provides new apprentices with basic information needed to protect themselves from falls from heights early in their training, and extends this training to more detailed construction processes later in the apprenticeship. We have developed an integrated fall prevention curriculum that demonstrates the importance of fall prevention throughout the 4-year apprenticeship. Despite streamlining processes to continually monitor delivery of the curriculum and drive the iterative process of curriculum revision, formal methods of documenting quality assurance and quality improvement continue to challenge the team members. We hope that long-term monitoring of this project will continue to ensure that the revised curriculum is maintained and improved.

The research team is currently measuring the outcomes of this project through apprentice survey and residential worksite audits, with encouraging initial results. We expect to see improvements in those areas targeted in the revised curriculum, such as perception of risks for tasks where falls commonly occur, knowledge of methods to work around unprotected openings, and truss installation behaviors at the worksite, to name a few. This project has led to identification of other areas of intervention that our team has pursued for future projects, such as mentorship at the worksite, crew supervision, and greater use of available fall-prevention technologies.

Our work confirms the high risk of falls among residential apprentice carpenters and the fact that many apprentice carpenters do not have the knowledge, skills, and support from journeymen to ensure that they work safely at heights required throughout the home construction process. These apprentices lacked knowledge of basic federal safety standards and they did not use basic fall prevention techniques at residential worksites. When they had received training at school, they found actual experiences in the field to be quite different from what they were taught.

Acknowledgements

The authors would like to acknowledge Barry Stelzer, Lynda Mueller Drendel, Todd Erdman, Leonard Harris and Mike Short for their diligent work in designing and delivering the revised fall prevention training program at the Carpenters' Joint Apprenticeship Program.

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