울산대학교 UNIVERSITY OF ULSAN

# A Basic Study on the Improvement of Safety Education for Construction Workers Using Virtual Reality Simulation

**July 6, 2018**

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# Contents

# 1. Introduction

- In the past, the construction project aimed a rate of return through reduction of cost and schedule while safety management has been neglected.
- The high accident and fatality rate is attributed to corporations' insufficient focus on prevention, due to the additional expense and work hours required at worksites (Huang and Hinze, 2006).
- Considering the fact that many high-rise work-sites involve a number of repetitive tasks, the positive influence of accident prevention training is especially highly anticipated.
- To resolve this problem, ICT are recently being tried. Therefore, the objective is to suggest education contents applying virtual reality simulation for improvement of construction safety education.

# 2. Existing Method of Construction Safety

## 2.1 Existing Method

- Vertical communication Method
- One-sided lesson Method
- Based Learner-centered Passive learning
- Instructor-centered education

(a)

(b)

(c)

**Figure 1.** Existing examples of Construction Safety

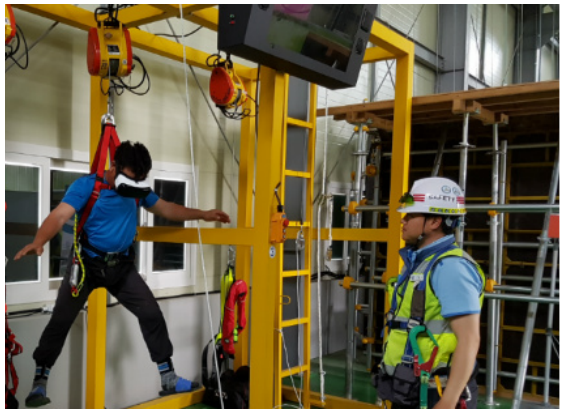
# 3. Literature Review

| Researcher | Title | Contents |
|---|---|---|
| Dale (1969) | Audio-visual methods in teaching | This study is suggested that inducing learners' interest can contribute to improving memory of the content instructed. |
| Burke et al. (2006) | The relative effectiveness of worker safety and health training methods. | This study is to determine the relative effectiveness of different methods of worker safety by using Ninety-five quasi-experimental studies. |
| Li et al. (2012) | Visualizing safety assessment by integrating the use of game technology | This study is suggested that a new safety assessment method, termed the 4D interactive Safety Assessment, which offers an improvement. By using safety performance of construction workers in Hong Kong. |
| Son (2013) | Development of a Student-Centered Leaning Tool for Construction Safety Education in a Virtual Reality Environment | This study is to develop a tool for safety education using virtual reality technology. And pilot test with 10 students showed positive results. |
| Lee and Hollar (2013) | Probing BIM Education in Construction Engineering and Management Programs Using Industry Perceptions | This study is to utilize Building Information Modeling (BIM) technology and Virtual Design and Construction (VDC) practices to benefit from improved collaboration through the capability of visual communication. |
| Sulankivi et al. (2010) | 4D-BIM for Construction Safety Planning | The study is conducted on-going research project called BIM Safety (BIM-based Safety management and Communication System) and suggested how four-dimensional site layout and safety related planning activities can be carried out by using the currently available BIM software. |

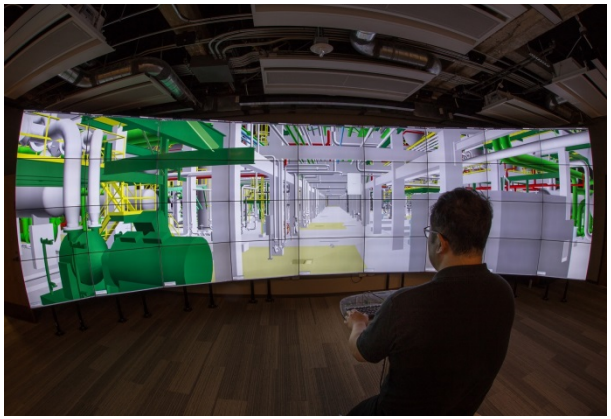
# 4. ICT + Safety Method of Construction Safety

## 4.1 ICT + Safety Method

- Active learning
- Learning program Based on Learner-driven
- Integration of the learning environment
- Learner's educational Satisfying requirements



(a)



(b)

(c)

**Figure 2.** ICT + Safety examples of Construction Safety

# 5. Deduction and suitability

- The OSHA accident prevention education and worksite inspection
- Specifically, it suggests standards that are applicable to a large number of accidents in any type of worksite.
- Also KOSHA is Korea Occupational Safety & Health Agency
- This study  the OSHA & KOSHA standards are selectively applied to worksite safety management depending on the construction worksite category.
- Deduct Standard Element by using Delphi Techique
- categorizes the items by 11 work sections and 36 specific work-types. Each item includes a variety of accident types. In this paper, the major accident types, those ranked at more than 3.0 points in both occurrence severity and management importance, are addressed.

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# 5. Deduction and suitability

| Work Type | Details | Accident types | Occurrence Severity | Management Importance |
|---|---|---|---|---|
| **Temporary** | Scaffold/safety net | Falling object while carrying materials | 3.267 | 3.830 |
| **Temporary** | Scaffold/safety net | Fall due to not wearing personal protective equipment during erecting and dismantling | 3.345 | 4.006 |
| **Temporary** | Scaffold/safety net | Falling object during erecting and dismantling | 3.552 | 4.012 |
| **Earth** | Const. equipment | Crash due to not wearing personal protective equipment (PPE) | 3.000 | 3.685 |
| **Earth** | Excavation | Fall or tumble down an excavation site edge | 3.024 | 3.758 |
| **Earth** | Excavation | Hit into the back side while excavating equipment is rotating | 3.176 | 3.733 |
| **Earth** | Excavation | Collapse of excavation side due to over cutting slope or over-excavation | 3.248 | 3.915 |
| **Foundation** | Pile driving | Equipment collapse due to ground sinking of the underbody of equipment | 3.109 | 3.964 |
| **Foundation** | Pile driving | Impact between equipment and labor working under equipment | 3.030 | 3.642 |
| **Foundation** | Pile driving | Collapse of the operating driving pile machine | 3.085 | 3.891 |

# 5. Deduction and suitability

| Work Type | Details | Accident types | Occurrence Severity | Management Importance |
|---|---|---|---|---|
| **Structure** | Preparation | Falling material by single wire while carrying freight | 3.073 | 3.715 |
| **Structure** | Gang form | Fall due to non-installation of safe guard-rails on work platform for form installation | 3.345 | 3.921 |
| **Structure** | Gang form | Fall due to non-installation of opening cover during installation of form | 3.370 | 3.982 |
| **Structure** | Rebar assembly | Being impaled by rebar while working without wearing PPE | 3.012 | 3.497 |
| **Structure** | Shore | Fall due to non-installation of safe guardrails on movable scaffolding | 3.236 | 3.836 |
| **Structure** | Shore | Collision with shore while not wearing PPE | 3.024 | 3.521 |
| **Structure** | Concrete pour | Collapse of shore while pouring concrete | 3.261 | 4.097 |
| **Structure** | Form removal | Dropping of form on the worker during removal | 3.303 | 3.764 |
| **Structure** | Form removal | Fall by applying excessive strength while removing form | 3.248 | 3.685 |
| **Masonry** | Masonry | Fall caused by lack of safety measures around openings | 3.097 | 3.794 |
| **Masonry** | Masonry | Fall due to failure to install elevating ladder & safety guardrail on movable scaffolding | 3.188 | 3.745 |

# 5. Deduction and suitability

| Work Type | Details | Accident types | Occurrence Severity | Management Importance |
|---|---|---|---|---|
| **Plaster** | Plaster work | Fall caused by poorly installed scaffolding and work plate | 3.164 | 3.794 |
| **Plaster** | Plaster work | Fall caused by unfastened rope on suspended scaffolding during plaster work | 3.042 | 4.042 |
| **Plaster** | Plaster work | Fall due to non-installation of safety guardrails on movable scaffolding | 3.188 | 3.964 |
| **Water proofing** | Membrane | Improper installation of movable scaffolding when working at a high altitude | 3.158 | 3.788 |
| **Water proofing** | Membrane | Fall due to noncompliance of protective measures, including safety guardrail | 3.085 | 3.630 |
| **Water proofing** | Finish | Falling openings while cleaning the opening covers | 3.000 | 3.691 |
| **Roofing** | Preparation | Falling materials due to lifting materials with improperly bound tower crane | 3.061 | 3.794 |
| **Roofing** | Preparation | Falling materials due to unstable loading on the top of sloped roof | 3.212 | 3.891 |
| **Roofing** | Preparation | Falling materials due to using a single wire when lifting light gauge steel materials | 3.097 | 3.782 |
| **Roofing** | Installation | Falling materials due to wind while installing roof truss | 3.206 | 3.830 |
| **Window/Door** | Installation | Fall due to losing balance while finishing building edges | 3.230 | 3.952 |
| **Window/Door** | Window/Door | Leaning out too far when caulking at window frames | 3.109 | 3.885 |
| **Painting** | Preparation | Fall due to not fastening scaffolding belt or rope with vertical lifeline | 3.091 | 3.952 |
| **Painting** | Preparation | Fall during surface treatment on work platforms | 3.000 | 3.752 |
| **Painting** | Painting | Fire while painting near welding work place | 3.164 | 3.964 |
| **Painting** | Painting | Fall while using ladder when working at a high altitude | 3.200 | 3.964 |
| **Electric/Mech.** | Electric/Mech. | Fall from ladder during wiring work | 3.067 | 3.727 |
| **Electric/Mech.** | Electric/Mech. | Fire or explosion caused by an electrical spark | 3.042 | 3.764 |
| **Electric/Mech.** | E/V | Fall into openings on machine room floors or on each floor while carrying materials into pits | 3.103 | 3.818 |
| **Electric/Mech.** | E/V | Fall due to failure to install safety railing on elevator floor and ceiling edge | 3.061 | 3.867 |

# 7. Conclusion

- Enhancement of safety training can be achieved by simplifying educational content and by applying advancements to the instructional delivery.
- To improve the efficiency of understanding the safety education content
- This research suggested the material to accident types applicable only to Korean high-rise condominium construction sites as found by the Delphi technique
- To examine the validity of the assigned weighted values, a qualitative analysis was conducted on the actual probability of the suggested accident types in South Korea.
- The suggested accident types were found appropriate for use in safety training.

# Thank you for your attention !