An Experimental Investigation of Human Performance Differences Depending on Simulator Complexity

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1. Introduction

As a different approach for collecting human reliability analysis (HRA) data—compared to full-scope simulator studies—Idaho National Laboratory (INL) attempted to gather HRA data via the Simplified Human Error Experimental Program (SHEEP), which employs a simplified simulator and student participants [1-3]. To date, INL has considered implementing the SHEEP approach using simplified simulators such as Rancor Microworld [1] and the Compact Nuclear Simulator (CNS) [4] to complement—not replace—full-scope studies, as well as to primarily collect HRA data for estimating the nominal/basic human error probabilities needed in the HRA quantification process.

This study is a part of a project that aims to suggest methods of supporting full-scope data collection studies based on SHEEP. This paper first introduces the major tasks within the SHEEP framework. It then primarily focuses on one major task in particular; namely, how and why we plan to experimentally investigate human performance differences that depend on simulator complexity.

2. SHEEP Framework

Fig. 1 shows the SHEEP framework, which represents an ongoing effort to provide additional data to support and complement full-scope studies. The framework consists of three steps: (1) identification of HRA items collectible in a simplified simulator, (2) treatment of these HRA items based on experiments, and (3) integration of the data into a full-scope database for deployment in HRA methods.

The first step classifies all HRA data items collectible in any type of simulator into two groups: (1) items collectible in both simplified and full-scope simulators, and (2) items only collectible in simplified simulators. The second step suggests how experimentation can be used to treat the relevant HRA items classified in the first step. For the HRA items collectible in both simplified and full-scope simulators, this step involves differentiating the participant type (i.e., operator vs. student) and simulator complexity (i.e., simplified vs. full-scope). This study design sets the stage for collecting the data needed to develop full-scope inference models in the next step. In the case of the HRA items that can only be collected in a simplified simulator, this step contributes to gathering new HRA data that are missed by full-scope simulators. The last step entails integrating experimental data obtained in the previous step into a comprehensive or full-scope database and potentially incorporating into HRA methods.

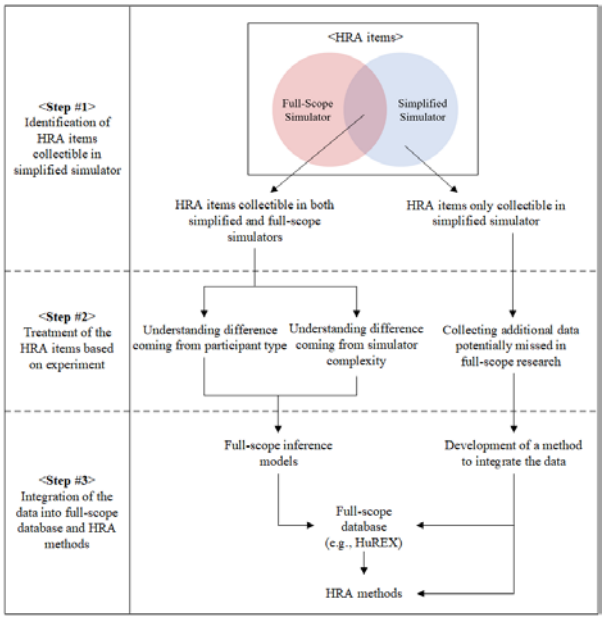

Fig. 1. SHEEP Framework

This paper mainly discusses how to treat the HRA items collectible in both simplified and full-scope simulators. For these items, inference models are planned to be developed, based on differences arising due to participant type and simulator complexity. Fig. 2 shows the detailed process of inferring full-scope data based on simplified simulator data. The error data from students and operators when using a less simplified simulator (e.g., CNS [4]) or a more simplified simulator (e.g., Rancor Microworld [1]) are collected through experiments. Then, by developing a method to define the gaps (1) between students and operators, (2) between the simplified simulators, and (3) between the simplified

simulator and the full-scope simulator, the operator data for the full-scope environment is inferred using the student data from the simplified simulators.

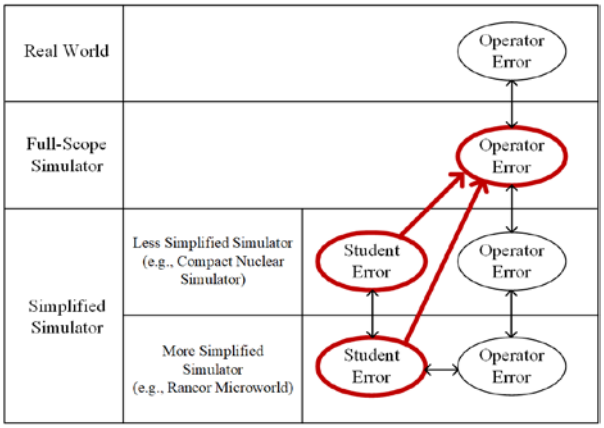

Fig. 2. Process to Infer Full-Scope Data Based on Simplified Simulator Data

3. Experiment Plan

In previous studies [2, 5], we collected human performance data to understand the differences between students and actual operators when using Rancor Microworld (i.e., a more simplified simulator). In this study, we collect human performance data based on CNS (i.e., a less simplified simulator) (see Fig. 3), then compare these data with those collected in the previous studies, thus enabling a determination of the differences arising from simulator complexity.

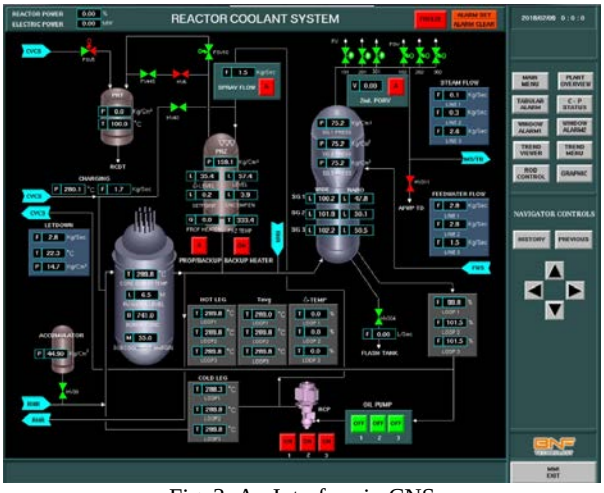

Fig. 3. An Interface in CNS

In the study, we employ an experimental design similar to that used in the previous studies. Table 1 shows a randomized factorial experiment design modified from the previous studies. The four scenarios implementable in both CNS and Rancor Microworld are considered in the experiment. As with the previous experiment, 20 students and operators participated.

Table 1. Randomized Factorial Experiment Design

Event Class	Participant Type		Scenario
	Actual Operator	Student	
Non-Event			· Fully auto startup (0% to 100%) · Shutdown (100% to 0%)
Event			· Steam generator tube rupture with an indicator failure · Loss of feed-water pump

4. Conclusions

This paper introduces the SHEEP approach to support full-scope data collection, along with our plan to experimentally investigate human performance differences depending on simulator complexity. The outcomes of the experiment will be discussed at the conference.

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