ASSESSING THE USABILITY OF A DESKTOP SIMULATOR FOR TRAINING INSTRUMENT FLIGHT RULES (IFR) PROCEDURES

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Abstract: The aviation industry has used simulator training devices as an inexpensive and safe alternative to flight training for decades. Many different simulation types have been developed, with varying quality levels in fidelity and realism. The study aim is to evaluate the the usability of the RedBird JAY desktop simulator for training Instrument Flight Rules (IFR) procedures. Spradley's (2016) domain analysis is used to identify common themes in the participant's responses. Twelve pilots, holding an FAA private pilot certificate and instrument rating as a minimum and with mixed prior simulator experience, operated a Redbird JAY flight simulator configured with the Cessna 172 using standard analog instruments with a separate horizontal situation indicator (HIS) and Garmin G1000 integrated flight instrument system. Each participant was given three scenarios, consisting of approximately five minutes of flying in identical conditions for all participants. The results and future research areas are discussed in this paper.

Key Words: *Simulators, flight training,*

1. INTRODUCTION

The aviation industry has used simulator training devices as an inexpensive and safe alternative to flight training for decades. Many different simulation types have been developed, with varying quality levels in fidelity and realism. This study aims to evaluate the the usability of the RedBird JAY desktop simulator for training Instrument Flight Rules (IFR) procedures. The RedBird JAY simulator is a relatively affordable option for pilots wishing to practice flight procedures.

The RedBird JAY simulator is a relatively affordable option for pilots wishing to practice flight procedures. For the simulator to be useful, it must be usable for pilots. The unlimited practice it provides will only be useful if the pilots operating the simulator understand it and deem it realistic enough to be helpful. This study will help determine whether or not the JAY simulator is a useful tool for pilot IFR operations.

2. LITERATURE REVIEW

The Flight simulators can be useful tools for flight instruction if properly used; however, they are not perfect like all tools. Fassel et al. (2019) studied the usability of a flight simulator with 23 collegiate aviation students. Participants were asked to perform five tasks in random order and report the difficulty experienced while conducting the task. Although the participants generally reported through the post-

survey System Usability Scale that the simulator was easy to operate and understand, an artifact of the study became evident in confusion over control buttons.

Forrest (1999) conducted a similar usability study with six certificated flight instructors operating a Personal Computer Aviation Training Device (PCATD). Participants provided a cognitive walkthrough and answered a post-survey heuristic questionnaire. Areas of concern included spasmodic control feedback and complaints about the small size of buttons and switches.

Spradley's (2016) domain analysis is useful in determining common themes and conjectures from domains, cover terms, and included terms from participant's responses. Each conjecture is then further defined into child nodes as included terms and cover terms to be in alignment with Spradley's domain analysis. Each of the conjecture has a cover term, but every conjecture does not have a corresponding included term. Palmquist (2018) identified advantages and disadvantages of using a content analysis. Advantagest include that the analysis directly views communication, provides historical and cultural insights, and allows categories and relationships to emerge from the coding of participant responses. Disadvantages include this method being time consuming, errors could occur if the researchers are too liberal in drawing influences or relationships, and is difficult to automate.

3. METHODOLOGY

The usability study documentation was developed and submitted to the Institutional Review Board (IRB). Once IRB approval was authorized, participants were recruited. The partipants consisted of twelve pilots, holding an FAA private pilot certificate and instrument rating as a minimum and with mixed prior simulator experience. During the study, the participants operated a Redbird JAY flight simulator configured with the Cessna 172 using standard analog instruments with a separate horizontal situation indicator (HIS) and Garmin G1000 integrated flight instrument system. Each participant was provided with three scenarios, each consisting of approximately five minutes of flying.

The first scenario consisted of five minutes of free-flight in Visual Flight Rules (VFR) conditions with the aircraft configured with analog gauges, allowing the participant to familiarize themselves with the simulator. The scenarios were initiated from Melbourne International Airport (KMLB) runway 09R, with participants requested not to crash the aircraft intentionally. In the second scenario, the participants were tasked with flying a straight-in ILS approach to KLMB runway 09R (33' MSL) to a full stop with the aircraft configured for analog gauges. Each scenario was initiated with the aircraft airborne at 1950' MSL in IMC conditions 7 NM from the runway, with a cloud base of 800' AGL. The aircraft was configured before initiating the flight for the approach, aligned with the localizer and glideslope, and an optional short explanation of the instruments for participants unfamiliar with the analog setup. The third scenario was identical to scenario two but with the aircraft configured with the Garmin G1000 instead of analog instruments.

The study data was analyzed and the descriptive statistics and the results from using Spradley's (2016) domain analysis are discussed in the results section. The domain analysis was useful in determining common themes and conjectures from domains, cover terms, and included terms from participant's responses from the three open-ended responses on the most liked and least liked aspects of the simulator and improvement recommendations using desktop simulators for aviation instrument training.

4. RESULTS

This section discusses the study results. The first part of this sections discusses the descriptive statistics. The second part of this section identifies the common themes from using Spradley's (2016) Domain Analysis.

4.1 Descriptive Statistics

4.1.1 Realism

The results from the first study question highlighted that the most common answer for "How realistic was the simulated flight compared to actual flight?" was somewhat realistic. Seven out of the 12 participants chose that the simulator portrayed a somewhat realistic flight compared to an actual flight. The mean was calculated as 3.58, and the variance was 0.74 with a standard deviation of 0.86.

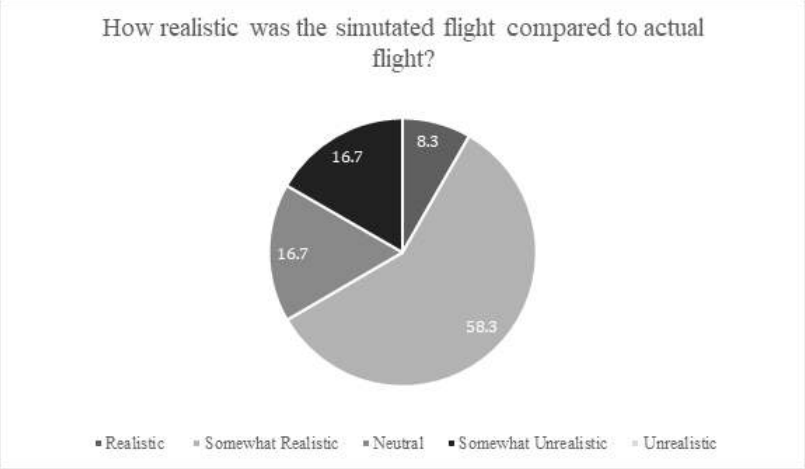

Figure 1 Realism of Simulator

4.1.2 Similarity to Other Training Simulators

Most participants selected that they strongly agreed or just agreed with the statement that "Depending on your experience, this simulator performs similarly to other training simulators." Four out of 12 participants selected that they *strongly agreed*, with five participants selected that they *agreed* with the statement. Therefore, there was a total of 75% of the participants that *agreed*. Also, the mean was calculated as 3.75, with a high variance of 1.69 and standard deviation of 1.30.

4.1.3 Maneuverability

The participants' views on the maneuverability component of the simulator differed. There was a mix of answers when the participants were asked, "how easy was it to maneuver this simulator?" Out of the 12 participants, 66.6% of the responses stated that the simulator was *easy* and *moderate* on the scale of how easy it was to maneuver. This is directly related to the mean calculated. The mean of 3.50 shows that there was a direct split between the answers *easy* and *moderate*. In addition, other descriptive statistics include the variance of 0.92 and the standard deviation of 0.96.

4.1.4 Beneficial

Similar to when the answers were analyzed for how similar the simulator is compared to other training simulators, the results from the question regarding how beneficial the simulator is varied in responses. Based on the range from *non-beneficial* to *very beneficial*, the participants were asked to score "how beneficial do you believe this simulator is?" The mean was 3.33, which correlates with the answer closest to *moderately beneficial*. The variance and standard deviation both suggest the widespread of answers due to both of these being high. The variance calculated was 1.72, and the standard deviation was 1.31.

4.1.5 Clarity

Based on the results of the question "how clear are the instructions to fly the simulator," most participants found it to be very clear. All 12 of the participants were asked this question on the unclear to very clear scale, and all the participants selected either *very clear* (11 participants) or *clear* (one survey respondent). The mean of the results was 4.92, which correlates directly to the answer, *very clear*. The variance and standard deviation were very low due to most participants selecting that the instructions to fly the simulator were *very clear*. The variance was 0.08, and the standard deviation of 0.28.

4.1.6 Comparing Approaches

When participants were asked, "Which approach was the easiest?" all 12 participants selected that the ILS with glass display was the easiest. Descriptive statistics were not needed to express the results from this question because 100% of the participants' answers were toward the ILS approach with the glass cockpit display.

4.1.7 Effectiveness for IFR Training and Pilot Practice

There are two questions that asked participants about the effectiveness of the simulator for IFR training or IFR pilot practice. For the IFR training question, a Likert scale of *ineffective* to *very effective* was used. No participants selected that it would be *very effective*, but 66.6% of the responses were either *effective* (four participants) or *moderately effective* (four participants). The descriptive statistics include the mean, 2.83, a variance of 1.14, and the standard deviation of 1.07. Both the standard deviation and variance were high due to the widespread responses.

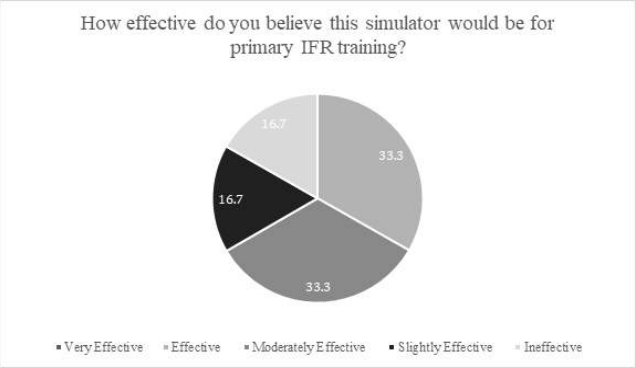

Figure 2 Effectiveness for Primary IFR Training

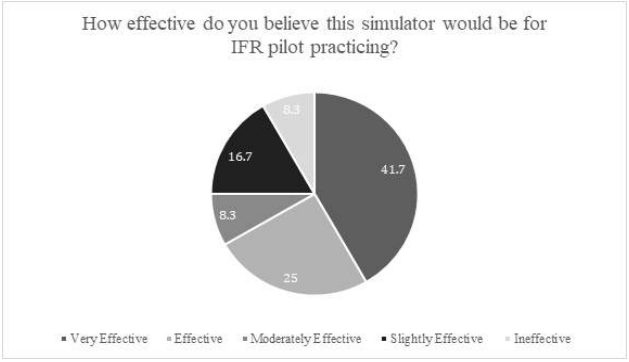

Figure 3 Effectiveness of Simulator for IFR Pilot Practice

Additionally, when participants were asked the same question but with the simulator's purpose being useful for IFR pilot practice rather than training, 41.7% of participants selected that it would be very effective (five participants). Due to many participants having different views on the simulator, its effectiveness differed with partcipants' responses. The mean was calculated as 3.75 with the standard deviation of 1.36 and the variance to be 1.85. The standard deviation and variance are high due to the participants' selection varying based on the simulator being effective.

4.2 Domain Analysis

Three open-ended responses were included in the questionnaire to gather information on the most liked and least liked aspects of the simulator and improvement recommendations. A summary of participant responses following Spradley's (2016) Domain Analysis is discussed regarding using desktop simulators for aviation instrument training. Domain 1, most liked aspects of displays, is summarized in Table 1. The most liked aspects included flight instruments sensitive to small corrections and ease of use operating the simulator. The cover terms *Instrument Representation* and *Ease of Use* were applied with included terms being *Realism* and *Flight Instruments*. For example, participant 4 (P4) reported "it does a good job for teaching small corrections for IFR," P5 stated "the instruments looked and felt realistic," and P7 reported "familiarity with G1000."

Table 1 Domain 1 Analysis

Domain 1	Cover Term	Included Term	Conjectures
Most Liked Aspects of Displays	Instrument Representativeness	Realism	1.1. Flight controls similar to actual aircraft
			1.2. Realistic instruments provided familiarity
	Ease of Use	Flight instruments	1.3. Responsive to small corrections
			1.4. Simple to operate

Domain 2, least liked aspects of displays, is summarized in Table 2. The cover term was *Controls* and the included terms were *Tactile* and *Performance.* Responses include P3 stating that the "yolk is extremely hard to control. Much harder than the actual aircraft. Rudder pedals extremely touchy," P4 stated "control inputs had to be a lot smaller than the actual aircraft," P6 stated that "the rudder was way too sensitive and the steam gauges seemed to have a slight lag," and P8 stated that "the instruments didn't always turn smoothly in the steam gauge cockpit, they seemed to lag a bit."

Table 2 Domain 2 Analysis

Domain 2	Cover Term	Included Term	Conjectures
Least Liked Aspects of Displays	Controls	Tactile	2.1. Inaccurate control feedback
			2.2. Difficulty moving controls precisely
		Performance	2.3. Analog instrument lag
			2.4. Improve control feedback
			2.5. Physical buttons and switches

Domain 3, simulator improvements, is displayed in Table 3. When asked for simulator improvement suggestions, participants noted limited tactility. The cover term is *Tactile* and the included term is *Usability*. P7 suggested "being able to manipulate switches and knobs easier," P11 suggested "being able to access more buttons," P12 stated "less responsive control inputs," and P3 suggested "adjusting yoke and rudder control."

Table 3 Domain 3 Analysis

Domain 3	Cover Term	Included Term	Conjectures
Simulator Improvements	Tactile	Usability	3.1. Easy to manipulate controls
			3.2. Accessiblity
			3.3. Adjustability

5. CONCLUSION

The study findings suggests that the RedBird Jay simulator is usable for instrument flight training. The simulator screen reacts to small movements necessary for approach flying and would be useful in teaching pilots the importance of small adjustments. Areas of improvement are related to the physical hardware associated with the simulator. Adjustments to the yolk and rudder pedals would be advised to ensure the deflection of such controls is as similar as possible to the actual aircraft. The inclusion of physical buttons and switches would also provide pilots the opportunity to build procedure muscle memory.

Future research studies consist of conducting a survey, recruitment of pilots, and having participants share their perceptions on the importance of simulator characteristics for the purposes of training and practice. Another future research area is to test different simulator displays, RedBird and others, to gather data on what pilots need most from virtual training. Furthermore, a study could be conducted to measure the transfer of training from simulated training to real-world performance through the use of different simulators and displays to analyze pilot performance with regards to those different simulators and displays.

6. REFERENCES

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