Available online at http://docs.lib.purdue.edu/jate

JATE

Journal of Aviation Technology and Engineering 9:1 (2020) 32–40

Does the Use of Simulation Significantly Impact Students' Perceptions of Their Air Traffic Control Knowledge and Skill?

Meron Lindenfeld, Jeanne Radigan, and Michael Figuccio

Farmingdale State College

Abstract

Simulation has served as an instructional supplement in education and training within various fields such as nursing, business, and flight training. Prior research studies have documented its usefulness. Simulation-based lessons have also been used for air traffic control (ATC) training, but little research has been conducted on the usefulness of simulation in this application. This study measured the level of influence that ATC simulation had on students' perception of their ATC knowledge and skill level and their commitment to a career in ATC.

Data were collected by surveying students at four institutions of higher education after they completed ATC courses that utilized simulation exercises. The survey measured the students' perceptions of their ATC knowledge and skill level, as well as their commitment to a career in ATC, before and after they took ATC simulation courses. The results indicated that the students were more committed to a career in ATC, and that students' perceived level of ATC knowledge and skill increased after they took the ATC simulation lab course. The study further revealed that moderate relationships exist between students' perceived ATC knowledge and skill level, and their commitment to a career in ATC. This study also discussed the importance of students identifying within their college career whether or not they are in the field of study and career path that is right for them, and how simulation may help students identify this early.

Keywords: simulation, ATC, air traffic control, ATC knowledge, ATC skill

Introduction and Purpose of the Study

College students in the United States change their major three times on average before completing a degree program (Ramos, 2013). This staggering statistic is most likely the result of students realizing they do not have the aptitude to continue in a course of study, they do not have the needed financial resources to continue (as is often the case in aviation degrees requiring flight training), or that they have simply lost interest in their chosen field and prefer to try a different degree program. Commitment to any degree program may be affected by students' perceived level of their ability and/or aptitude for any given field. We tend to be more motivated to put in extra effort in areas of our strengths. For example, students that perceive themselves as strong in math are motivated to challenge themselves in more advanced mathematical topics. They would be much more likely to pursue a career path that involves mathematical skill than an individual who

http://dx.doi.org/10.7771/2159-6670.1203

struggles in math. Research has demonstrated that in the face of pressing situational demands, a strong sense of efficacy is often needed to persevere (Bandura, 1993). While mathematics and similar fields may allow students to identify their aptitudes early in their education, for other challenging skill-based fields it may be more difficult to identify the aptitude level from traditional knowledge-based courses. Additionally, while knowledge- and skill-based assessments might provide students with a quantitative indication of how they perform, the researchers felt it was important to examine if students perceive they can actually apply the knowledge that was measured. It is this perception that may lead to a stronger self-efficacy, which provides students with the confidence to persevere through academic challenges, as observed by Bandura (1993). Goldenberg, Andrusyszyn, and Iwasiw (2005) suggest students' self-efficacy level could impact their performance level. Since self-efficacy is greatly influenced by what they perceive they are capable of, students who have the opportunity to practice applying their knowledge in simulators will have more confidence in their ability to perform related tasks.

The purpose of this study was to examine the impact that simulation exercises had on students' perceived air traffic control (ATC) knowledge and skill, as well as their commitment to a career in ATC, before and after taking a course that utilized ATC simulation. This study also set out to ascertain whether or not students' perception of their ATC knowledge and skill was related to their commitment to a career in ATC.

Review of the Literature

Use of Simulation

Simulation exercises for educational purposes have had much success, as documented in the fields of nursing (Brannan, White, & Bezanson, 2008; Cimino, 2009), business (Cadotte, 1995; Vescoukis, Retalis, & Anagnostopoulos, 2003), and flight training (Lintern, 1992; Rehmann, 1995), yet there is a void of research on the impact of simulation exercises for students in ATC courses.

Simulation exercises typically require the participant to execute a skill to achieve the established goal by utilizing some form of knowledge that is related to the task at hand. It is often felt that simulation actually provides better training than what can be accomplished "in the real world" by offering a greater variety of scenarios for the learners in a more condensed amount of time than they otherwise might have experienced (Galarneau, 2005). When a simulation exercise requiring both knowledge and skill is accomplished, it can be inferred that a transfer of knowledge to skill has occurred.

Knowledge Transfer

For the purpose of this study, ATC knowledge was defined operationally as the knowledge and understanding of terms, concepts, and theories acquired from classroom instruction, assigned readings, and simulation exercises in ATC.

An interesting study by Foster (2011) has provided empirical findings of learning that occurred as a result of playing a video game made by Atari called Roller Coaster Tycoon 3 (RCT3). RCT3 is a single-player video game that challenges one to build and manage an amusement park. The average age of the participants was 11. Foster had the students play RCT3 for approximately two hours in the afternoon, twice a week, for seven weeks. The students' knowledge related to economics and social studies was assessed before and after the seven-week period. The study revealed that participants gained statistically significant knowledge of microeconomic principles and social studies related to topics such as opportunity cost, supply and demand, scarcity, and ethical and social decisions, despite not having any formal instruction in basic economics. Students were able to learn through an innovative process designed in the game which had them applying concepts as they planned, built, operated, and managed their park. They had to meet their set objectives by planning ahead, drawing conclusions from observations, and reflecting on feedback provided from the game. The students were required to intervene as necessary or modify their choices based on feedback provided in the game to reach the set goal (Foster, 2011).

Although formal training and educational programs are not typically viewed as being as much fun as playing games, if designed to incorporate a game-style approach, students' interest may be held for longer periods, yielding higher levels of knowledge attained from any given lesson.

Skill Transfer

ATC skill was defined operationally as the coordination and/or dexterity to execute a given task, for the purpose of this study. It was considered as the developed ability and aptitude or learned power to do something. For many years, the Federal Aviation Administration (FAA) has certified the use of flight training devices (FTDs), commonly referred to as flight simulators, for pilot training as a replacement for some of the required flight hours in earning certificates and ratings. Flight simulators can accurately depict an aircraft's flight dynamics, behavior characteristics, and instrument panel, allowing students to acquire and develop the necessary skills to control the aircraft in a variety of situations (Lintern, 1992). Lintern's (1992) study specifically focused on the transfer of skills acquired in flight simulation for use in an aircraft, where the operating environment is often less forgiving when training attempts are not successful. Lintern's rationale was to investigate the viability of flight skill transfer, given the potential safety risks when training in an aircraft. Effective flight training is critical, yet flight instruction should be cost efficient as well. Simulation offers lower flight training costs and provides a safer training environment.

Simulator design must conform to principles that allow maximum skill transfer. To identify these principles, Lintern cited Gibson's (1979) ecological theory as a promising basis, which links human actions with perceptual information. Gibson referred to these perceptual cues as invariants, claiming invariants as critical to the execution of goal-directed behaviors.

Hunter (1971) theorized that the ability to transfer knowledge and skill attained from previous experiences to problem-solve in current situations is a critical factor in creating one's perceptions, insight, and reasoning. While she agreed that simulation provides learners the opportunity to attain knowledge and skills for transfer, she identified several key factors needed for this positive transfer to occur: similar environment; student mindset; and similarity of the activity. The simulation must mimic the true operating environment to the greatest extent possible and the simulated exercises need to be designed to reflect actual scenarios likely to be encountered in the real world. Hunter also noted the importance of teaching students how to recognize feelings of pressure or anxiety during the learning activity so they can develop the ability to shift to a more positive mindset. Hunter describes good simulation as the synthesis of these factors and as being necessary for the maximum transfer of skills to occur.

Hunter's belief of the importance of utilizing a "good simulation" model for maximum transfer of skills was supported in a study that examined the benefit of utilizing simulation to develop pilot skills in aircraft upset recovery (Rogers, Boguet Howell, & DeJohn, 2009). In that study, one group of pilots received prior training on personal computers in aircraft upset recovery using the Microsoft Flight Simulator program and the control group received no simulation training. Both groups were licensed private pilots with instrument ratings and all had completed a course in basic aerodynamics. Nine criteria were measured in four upset recovery attempts in an actual aircraft for both groups. The group with the simulator training outperformed the control group in six of the nine criteria. Further analysis of the data revealed that the simulator program failed to accurately depict the true flight characteristics related to the three criteria for which the simulator-trained group had not outperformed the control group. Conclusions were drawn that simulation exercises can improve performance only if they accurately replicate real-life tasks (Rogers et al., 2009).

Student ability to transfer instrument flight procedures practiced on a personal computer aviation training device (PC-ATD) was examined in a study by Taylor et al. (1997). Although PC-ATDs were not approved by the FAA for logging flight time, they offered a low-cost alternative to FTDs (flight simulators). In this study, all participants were previously exposed to basic and advanced instrument instruction. One group was given the opportunity to conduct lessons on a PC-ATD and then demonstrate proficiency on a given instrument flight task on the PC-ATD. They were then asked to demonstrate proficiency of the task in an aircraft. The average time spent on each lesson in the aircraft and the average time needed to demonstrate proficiency in the aircraft were recorded. The control group was given no practice on the PC-ATDs and all lessons were conducted in the actual aircraft. The times spent on each lesson and time to reach proficiency for the task were recorded for the control group. When the groups were compared, the effectiveness of the PC-ATDs in transferring skill was demonstrated. The control group needed four additional hours to demonstrate proficiency in the aircraft, suggesting that skill transfer had indeed occurred for the group that had practiced on the PC-ATD.

Further evidence of the effectiveness of utilizing flight simulation was demonstrated by a study on general aviation pilots' use of simulation to maintain proficiency in instrument flight skills (McDermott, 2006). Statistical analysis of the assessed tasks used to measure the pilots' proficiency of shooting their first and fourth ILS (instrument landing system) approaches, with and without simulation practice, was conducted. Those pilots with simulation practice performed significantly better on both approaches. A third analysis was conducted measuring both groups' improvement after four ILS approaches. Both groups did not show any significant rate of improvement after their fourth approach, suggesting that the benefit of simulation may reach a plateau after a certain level of training.

Self-efficacy

Academic self-efficacy describes a person's confidence in their abilities to organize, execute, and regulate performance to attain designated types of performances (Sharma and Nasa, 2014). Self-efficacy, or this confidence in our own ability to succeed, can impact which goals we choose to pursue, how we set out to attain these goals, and how we reflect upon our own performance. Individuals with a strong sense of self-efficacy tend to form a deeper interest in and a stronger sense of commitment to the activities they participate in to pursue their goals (Cherry, 2019).

Self-efficacy was central to psychologist Albert Bandura's social cognitive theory. Bandura (1977) found that performance accomplishments are especially influential on the level of self-efficacy because they are based on personal mastery experiences. Successes raise mastery expectations; repeated failures lower them, particularly if the mishaps occur early in the course of events. After strong efficacy expectations are developed through repeated success, the negative impact of occasional failures is likely to be reduced. The effects of failure of personal efficacy, therefore, partly depend on the timing and the total pattern of experiences in which the failures occur (Bandura, 1977). Simulation-based lessons could allow the maximization of positive impacts from accomplishments and minimize the negative impacts of failures through instructor-led persuasive verbal feedback provided at early stages.

Kim, Hwang, and Cho (2018) outlined the challenges of increased safety regulations that required nursing students take on passive roles of observation when learning in Korean hospital settings. To supplement such a limited practice environment, nursing universities run simulation-based practical training in which clinical situations are provided in a curriculum integrated with simulation education with problem-based learning (SIM-PBL) (Kim et al., 2018).

Kim et al. (2018) used a human patient simulator to provide four scenarios around a simulated colon cancer patient. The scenarios required nursing students to provide various levels of care. The research focused on challenges often faced by nursing students, which Kim et al. (2018) identified as communication apprehension with peers and superiors, lack of assertiveness, and low self-efficacy in clinical nursing care to patients. The data were collected pre- and post-SIM-PBL with a Likert-type survey measuring communication apprehension, assertiveness, and self-efficacy. They also measured satisfaction with simulation practical education.

Kim et al. (2018) reported that some aspects of communication apprehension decreased after simulation. Assertiveness was reported to be the same before and after simulation. However, self-efficacy in clinical nursing care had significantly increased after simulation.

Theorists of self-efficacy have outlined that, along with providing students opportunities to gain knowledge and skill, it is also important for students to perceive that they understand and can apply what they are learning. Simulation looks to be a promising tool to enhance these learning opportunities.

Methodology

Aviation students from four universities offering an ATC course were invited to participate in this study. All participants had completed a basic course in ATC with a lecture and laboratory component that utilized ATC simulation exercises. All simulation courses were conducted on high-fidelity-type simulators that utilized MaxSim™ ATC software by Adacel Technologies Limited or FIRSTplus ATC Training Simulator™ by Raytheon Canada Limited. Both software packages have similar capabilities. Of the four participating universities, two were located in the Northeast, one in the Southeast and one in the Midwest. Professors teaching the courses were mailed paper copies of the survey and were asked to distribute them at the conclusion of the course for voluntary student participation. The survey instructed them to first reflect and report their pre-course perceptions of their ATC knowledge and ATC skill, as well as their commitment to pursue a career in ATC. The survey also instructed students to report their post-course perceptions of their ATC knowledge and ATC skill, as well as their commitment to pursue a career in ATC.

The survey instrument collected demographic data, as well as their level of agreement with items designed to measure the variables. A six-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, 6 = strongly agree) was utilized to gauge the students' perceptions of their ATC knowledge, ATC skill, and their commitment to a career in ATC. The survey was juried by a panel of five professors to determine content validity. There were eight items designed to capture students' perception of their ATC knowledge, ten items to measure the perception of their ATC skill, and ten items to measure their commitment to a career in ATC.

Since Likert-scale ratings consist of ordinal data, non-parametric statistics were employed (Nanna & Sawilowsky, 1998). Statistical analyses were computed using IBM Statistical Package for Social Sciences (SPSS) Version 25. The median scores of the students' perceptions prior to the course and upon course completion were compared to generalize whether the use of simulation had an impact on their perceived ATC knowledge and ATC skill. Furthermore, Wilcoxon signed-ranks tests were utilized to compare the students' perceptions of their ATC knowledge, ATC skill, and their commitment to a career in ATC, before and after completing an ATC simulation course. Spearman rank correlations were utilized to examine the relationship between students' perception of their ATC knowledge and skill with their level of commitment to a career in ATC.

Results

Demographics

The majority of participants for this study were males (81.1%), aged 18–23 (85.6%). Table 1 presents a full distribution by age.

The students were fairly equally distributed by class rank, or credit-level status, with junior-level students at 30% making up the largest group. Class rank distribution for all participating students is given in Table 2.

Table 1
Demographics of the respondents—age.

Age ranges		Frequency	Percent	Valid percent	Cumulative percent
Valid	18 to 19	37	41.1	41.1	41.1
	20 to 21	30	33.4	33.4	74.5
	22 to 23	10	11.1	11.1	85.6
	24 to 25	6	6.6	6.6	92.2
	26 to 27	4	4.4	4.4	96.6
	28 +	3	3.3	3.3	100.0
	Total	90	100.0	100.0	

Table 2
Demographics of the respondents—class rank (credit level) status.

Credit status		Frequency	Percent	Valid percent	Cumulative percent
Valid	Freshman	24	26.7	27.0	27.0
	Sophomore	20	22.2	22.5	49.4
	Junior	27	30.0	30.3	79.8
	Senior	18	20.0	20.2	100.0
	Total	89	98.9	100.0	
Missing	System	1	1.1		
Total		90	100.0		

Table 3
Wilcoxon signed-ranks test comparing students' perceived ATC knowledge before and after simulation.

Dimension pair	N	Median	Z	p
ATC knowledge before	89	23	−8.15	<0.001
ATC knowledge after	89	44		

The results of comparing the students' perception of their ATC knowledge before and after the ATC simulation laboratory are given in Table 3.

Prior to taking the course, the median score for students' perception of their ATC knowledge was 23, based on the eight items used to measure this dimension, or 2.88 (23/8) if equating it to the six-point Likert scale. This suggests that students "slightly disagreed" that they had ATC knowledge prior to taking the simulation course.

After taking the course, the median score increased to 44, or 5.50 (44/8), suggesting that students agreed that they had ATC knowledge after the course.

A Wilcoxon signed-ranks test indicated that post-test ranks were significantly higher than pre-test ranks: $Z = -8.15$, $p < 0.001$. These results suggest that the students perceived a significant increase of their ATC knowledge after participating in the ATC simulation exercises, with the median score increasing by more than 19 points.

Table 4 highlights the results of the Wilcoxon signed-ranks test that was used to determine if there was a difference in students' perceptions of their ATC skill before and after the ATC simulation course.

Prior to taking the course, the median score for students' perception of their ATC skill was 20, based on the ten items used to measure this dimension, or 2.00 (20/10) if equating it to the six-point Likert scale. This suggests that students "slightly disagreed" that they had ATC skill prior to taking the simulation course.

After taking the course, the median score increased to 53, or 5.30 (53/10), suggesting that students agreed that they had ATC skill after the course.

A Wilcoxon signed-ranks test indicated that post-test ranks were significantly higher than pre-test ranks: $Z = -8.10$, $p < 0.001$. This suggests that students felt their ATC skill increased significantly after participating in the ATC simulation course.

Table 4
Wilcoxon signed-ranks test comparing students' perceived ATC skill before and after simulation.

Dimension pair	N	Median	Z	p
ATC skill before	87	20	−8.10	<0.001
ATC skill after	87	53		

Table 5
Wilcoxon signed-ranks test comparing students' perceived commitment to a career in ATC before (B) and after (A) simulation.

Dimension pair	N	Median	Z	p
Commit to career B	90	31	−5.89	<0.001
Commit to career A	90	46		

Table 5 highlights the results of the Wilcoxon signed-ranks test that was used to determine if there was a difference in students' perceptions of their commitment to a career in ATC before and after taking an ATC simulation course.

Prior to taking the course, the median score for students' commitment to a career in ATC was 31 based on the ten items used to measure this dimension, or 3.10 (31/10) if equating it to the six-point Likert scale. This suggests that students "slightly disagreed" that they were committed to a career in ATC prior to taking the simulation course.

After taking the course, the median increased to 46, or 4.60 (46/10), suggesting that students slightly agreed that they were committed to a career in ATC after the course.

A Wilcoxon signed-ranks test indicated that post-test ranks were significantly higher than pre-test ranks: $Z = -5.89$, $p < 0.001$. This suggests that students felt more committed to a career in ATC after participating in the ATC simulation course.

Spearman rank correlations were used to identify possible correlations between students' perceived level of ATC knowledge, ATC skill, and their commitment to a career in ATC.

The results shown in Table 6 indicate that students' perceived ATC knowledge and ATC skill were significantly correlated with their commitment to a career in ATC after taking the ATC simulation course. Furthermore, there was a significant correlation observed between students' perceived ATC knowledge and their perceived ATC skill.

Table 6
Correlations after simulation for students' perception of their ATC knowledge, ATC skill and their commitment to a career in ATC.

		Career commitment	ATC knowledge	ATC skill
Career commitment	*r*	1.000		
	p			
	N	90		
ATC knowledge	*r*	0.383**	1.000	
	p	<0.001		
	N	90	90	
ATC skill	*r*	0.417**	0.730**	1.000
	p	<0.001	<0.001	
	N	88	88	88

**Correlation is significant at the 0.01 level (2-tailed).

Conclusions and Recommendations

Prior research with nursing, business, and flight students has provided convincing evidence that simulation exercises can enhance the learning experience for students when the simulation exercises closely mimic the conditions one would expect to encounter in real-life scenarios. Little research has been conducted on the use of simulation as a viable tool for transferring the requisite knowledge and skillsets necessary to be successful as an air traffic controller. The results of this study confirm that students' perceptions of their ATC knowledge and skill increased significantly following a course that utilized ATC simulation exercises.

The result of having students' perception of their ATC knowledge increase following a course in ATC is not surprising, as one would expect to have their knowledge of any subject increase after taking a course and meeting the course objectives. Prior to taking the course, students' knowledge of air traffic control was most likely limited to prior reading, lectures, or multimedia presentations. Little to no opportunity of developing and/or practicing ATC skills would have been encountered, with the exception of some students that may have had some exposure through video games. The simulation course enabled students to put their theoretical knowledge into practice and develop the skills needed to control air traffic; in essence, it allowed students to "try out" this career path.

Students' perception of their ATC skill level increased significantly following their ATC simulation course, with an increase in the median score of 33 points. This increased perception of skill level may have led to a higher level of confidence in performing ATC tasks, leading to a higher career commitment in ATC. It would be logical to assume that with such a sizeable increase in perceived skill, an increase of similar magnitude in commitment to a career in ATC would also have been found. Interestingly enough, students "slightly disagreed" they were committed to a career in ATC before the course, and "slightly agreed" they were committed after the course, with an increase in median score of 15 points. One possible explanation for the increase in commitment may be due to the breakdown of students' majors. Of the surveys returned, 33% of the students were majoring in ATC and 66% of the students reported a different aviation major. The ATC majors may have already had a high level of commitment to a career in ATC that the course and simulation exercises reaffirmed, while some ATC majors may have experienced frustration and/or a low level of aptitude for the career that lowered their commitment. Conversely, the students not majoring in ATC may not have previously considered ATC as a career option. Those non-ATC majors that found the "work" to be interesting and/or discovered they had the aptitude to perform ATC tasks well might consider a career in ATC after they completed the course. Future research on the impact simulation has on career commitment might consider comparing ATC majors with non-majors.

A significant positive correlation was found between a commitment to a career in aviation and students' perception of their ATC knowledge and skill. One factor to consider may be that just because a student has increased their knowledge in a field, that alone might not be enough for them to believe they should commit to a particular major or career. Research into how to develop other aspects that a learner needs in order to increase motivation and commitment to a career should be considered. This may include how to help students develop their ability to identify and believe in what they can actually do, which Bandura (1993) refers to as self-efficacy. This may start with researching ways to further develop a student's academic self-efficacy, which Sharma and Nasa (2014) discuss as essential for an individual to believe they have the strength and self-confidence needed to endure challenges students face in their years of study. Bandura (1993) and Sharma and Nasa (2014) describe academic self-efficacy as a belief in the ability to perform necessary behaviors to produce a certain outcome.

Forbes classifies student debt as a "$1.5 trillion crisis"—and that number is referring to the debt level in the USA alone (Friedman, 2018). Perhaps offering simulation opportunities early in a college curriculum can allow students to find a major that "fits" early enough to avoid the negative impact found by Foraker (2012) when students change their major after the second year. The earlier a student finds a degree major that is right for them, the less detrimental it is to their success, the workforce, and the taxpayer. Higher education institutions that offer degree programs with courses conducive to using simulation should consider investing in this type of technology that enables students to identify early on whether a field of study is right for them.

References

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, *28*(2), 117–148.

Brannan, J. D., White, A., & Bezanson, J. L. (2008). Simulator effects on cognitive skills and confidence levels. *Journal of Nursing Administration*, *35*(3), 130–137.

Cadotte, E. R. (1995). *Business simulations: The next step in management training*. Retrieved October 2015, from http://www.marketplace-simulation.com/images/docs/next-step-in-management-training.pdf

Cherry, K. (2019, October). *Self efficacy and why believing in yourself matters*. Retrieved November 17, 2019, from http://www.verywellmind.com/what-is-self-efficacy-2795954

Cimino, L. M. (2009). *Newly hired registered nurse assessment abilities, critical thinking skills, confidence in assessment and critical thinking, self-efficacy, and orientation program evaluation in hospital settings utilizing and not utilizing simulation based orientation*. Retrieved February 2014, from http://www.dowling.edu/wp-content/uploads/2015/01/Linda-Marie-Cimino-Abstract.pdf

Foraker, M. J. (2012, April). *Does changing majors really affect the time to graduate? The impact of changing majors on student retention, graduation, and time to graduate*. Retrieved August 2015, from https://www.wku.edu/instres/documents/air_major_change.pdf

Foster, A. N. (2011). The process of learning in a simulation strategy game: Disciplinary knowledge construction. *Journal of Educational Research*, *45*(1), 1–27.

Friedman, Z. (2018, June 13). *Student loan debt statistics in 2018: A $1.5 trillion crisis*. Retrieved from https://www.forbes.com/sites/zackfriedman/2018/06/13/student-loan-debt-statistics-2018/#698735a77310

Galarneau, L. L. (2005). Authentic learning experiences through play: Games, simulations and the construction of knowledge. Available at SSRN: http://ssrn.com/abstract=810065 or http://dx.doi.org/10.2139/ssrn.810065 SOURCE: http://www.digra.org/digital-library/publications/authentic-learning-experiences-through-play-games-simulations-and-the-construction-of-knowledge/

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston, MA: Houghton Mifflin.

Goldenberg, D., Andrusyszyn, M., & Iwasiw, C. (2005). The effect of classroom simulation on nursing students' self-efficacy related to health teaching. *Journal of Nursing Education*, *44*(7), 310–314.

Hunter, M. C. (1971). *Teach for transfer*. Thousand Oaks, CA. *Corwin Press.*

Kim, Y. H., Hwang, K. H., & Cho, O. H. (2018). Simulation education with problem-based learning: Effect on nursing students' communication apprehension. *Social Behavior and Personality*, *46*(1), 151–160.

Lintern, G. (1992). Flight simulation for the study of skill transfer. *Simulation/Games for Learning*, *22*(4), 336–350.

McDermott, J. (2006). Computer-based flight simulation: A cost effective way for general aviation pilots to improve their instrument proficiency. *FAA International Journal of Applied Aviation Studies*, *6*(1), 155–163.

Nanna, M. J., & Sawilowsky, S. S. (1998). Analysis of Likert scale data in disability and medical rehabilitation research. *Psychological Methods*, *3*(1), 55–67.

Ramos, Y. (2013, March 15). *College students tend to change majors when they find the one they really love*. Retrieved February 8, 2016, from http://borderzine.com/2013/03/college-students-tend-to-change-majors-when-they-find-the-one-they-really-love/

Rehmann, A. J. (1995, December). *A handbook of flight simulation fidelity requirements for human factors research*. Retrieved January 20, 2014, from http://ntl.bts.gov/lib/000/800/858/tn95_46.pdf

Rogers, R. O., Boquet, A., Howell, C., & DeJohn, C. (2009, March). *An experiment to evaluate transfer of low-cost simulator-based upset recovery training*. Retrieved May 22, 2016, from http://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/2000s/media/200905.pdf

Sharma, H. L., & Nasa, G. (2014). Academic self-efficacy: A reliable predictor of educational performances. *British Journal of Education*, *2*(3), 57–64.

Taylor, H. L., Lintern, G., Hulin, C. L., Talleur, D., Emanuel, T., & Phillips, S. (1997). Transfer of training effectiveness of personal computer-based aviation training devices. *FAA National Technical Information Service*, 1–18.

Vescoukis, V. C., Retalis, S., & Anagnostopoulos, D. (2003). *Network-based business simulation activities in technical professional education*. Retrieved July 2015, from https://www.researchgate.net/publication/253127458_Network-Based_Business_Simulation_Activities_in_Technical_Professional_Education

Appendix

Your Perceptions Before and After Simulation

The following survey items are arranged in such a way that allows you to express how you felt about each topic before and after you experienced the air traffic control simulation exercises. For each item in this section, circle your level of agreement with the topic statements provided. To express how you felt about the topic *before* you experienced simulation exercises, select your choice on the column to the left side of the topic. To express how you felt about the topic *after* you experienced simulation exercises, select your choice on the column to the right side of the topic. Circling 1 indicates the strongest level of disagreement, circling 6 indicates the strongest level of agreement.

BeforeSimulation(B)	Your level of agreement with the topic before you took the ATC simulation lab course SD = Strongly Disagree SA = Strongly Agree	Topic	Your level of agreement with the topic after you took the ATC simulation lab course SD = Strongly Disagree SA = Strongly Agree	AfterSimulation(A)
		Air traffic control knowledge		
1B	SD → 1 2 3 4 5 6 ← SA	I know what the basic skills are to be successful as an air traffic controller	SD → 1 2 3 4 5 6 ← SA	1A
2B	SD → 1 2 3 4 5 6 ← SA	I know the basic differences in responsibilities of ground controllers, local controllers, departure and approach controllers, and center controllers	SD → 1 2 3 4 5 6 ← SA	2A
3B	SD → 1 2 3 4 5 6 ← SA	I know the layout of airports with respect to the way traffic flows on and around its runways, taxiways, terminals, etc.	SD → 1 2 3 4 5 6 ← SA	3A
4B	SD → 1 2 3 4 5 6 ← SA	I know the concept of giving a clearance	SD → 1 2 3 4 5 6 ← SA	4A
5B	SD → 1 2 3 4 5 6 ← SA	I know the specific phraseology controllers use to communicate	SD → 1 2 3 4 5 6 ← SA	5A
6B	SD → 1 2 3 4 5 6 ← SA	I know the purpose of vectors, altitude assignments, and speed control in order to ensure adequate aircraft separation	SD → 1 2 3 4 5 6 ← SA	6A
7B	SD → 1 2 3 4 5 6 ← SA	I know the purpose of aircraft spacing related to wake turbulence avoidance	SD → 1 2 3 4 5 6 ← SA	7A
8B	SD → 1 2 3 4 5 6 ← SA	I know the importance of coordination between air-traffic controllers to ensure the safe and expeditious flow of air traffic	SD → 1 2 3 4 5 6 ← SA	8A
		Air traffic control skill		
9B	SD → 1 2 3 4 5 6 ← SA	I am capable of executing the basic responsibilities of ground controllers, local controllers, departure and approach controllers, and center controllers	SD → 1 2 3 4 5 6 ← SA	9A
10B	SD → 1 2 3 4 5 6 ← SA	I am capable of issuing an ATC clearance correctly	SD → 1 2 3 4 5 6 ← SA	10A
11B	SD → 1 2 3 4 5 6 ← SA	I am capable of using the specific phraseology a controller uses to communicate	SD → 1 2 3 4 5 6 ← SA	11A
12B	SD → 1 2 3 4 5 6 ← SA	I am capable of using vectors, altitude assignments, and speed control in order to ensure adequate aircraft separation	SD → 1 2 3 4 5 6 ← SA	12A
13B	SD → 1 2 3 4 5 6 ← SA	I am capable of spacing aircraft for the purpose of wake turbulence avoidance	SD → 1 2 3 4 5 6 ← SA	13A
14B	SD → 1 2 3 4 5 6 ← SA	I am capable of using the equipment and tools available to an air traffic controller (radar scope, targets and data blocks, ranges, filters, prediction vectors, etc.)	SD → 1 2 3 4 5 6 ← SA	14A
15B	SD → 1 2 3 4 5 6 ← SA	I am capable of working with others to ensure the safe and expeditious flow of air traffic	SD → 1 2 3 4 5 6 ← SA	15A
16B	SD → 1 2 3 4 5 6 ← SA	I am confident I could apply appropriate phraseology while functioning as an air traffic controller	SD → 1 2 3 4 5 6 ← SA	16A
17B	SD → 1 2 3 4 5 6 ← SA	I am confident I can apply the usage of vectors, altitude assignments, and speed in order to ensure adequate aircraft separation	SD → 1 2 3 4 5 6 ← SA	17A

Appendix
(Continued)

BeforeSimulation(B)	Your level of agreement with the topic before you took the ATC simulation lab course SD = Strongly Disagree SA = Strongly Agree	Topic	Your level of agreement with the topic after you took the ATC simulation lab course SD = Strongly Disagree SA = Strongly Agree	AfterSimulation(A)
18B	SD → 1 2 3 4 5 6 ← SA	I am confident I can provide aircraft spacing related to wake turbulence avoidance	SD → 1 2 3 4 5 6 ← SA	18A
		Commitment to career in air traffic control		
19B	SD → 1 2 3 4 5 6 ← SA	I feel proud to be a student pursuing a career in air traffic control	SD → 1 2 3 4 5 6 ← SA	19A
20B	SD → 1 2 3 4 5 6 ← SA	I feel that I would like the job duties that are required of air traffic controllers	SD → 1 2 3 4 5 6 ← SA	20A
21B	SD → 1 2 3 4 5 6 ← SA	I feel satisfied to be in a degree program that will help me learn what I need in order to become an air traffic controller	SD → 1 2 3 4 5 6 ← SA	21A
22B	SD → 1 2 3 4 5 6 ← SA	I feel enthusiastic to be in the field of air traffic control	SD → 1 2 3 4 5 6 ← SA	22A
23B	SD → 1 2 3 4 5 6 ← SA	I feel that I want to become an air traffic controller	SD → 1 2 3 4 5 6 ← SA	23A
24B	SD → 1 2 3 4 5 6 ← SA	I feel that I am dedicated to becoming an air traffic controller	SD → 1 2 3 4 5 6 ← SA	24A
25B	SD → 1 2 3 4 5 6 ← SA	I feel that it would take a lot to get me to give up on my career interest of air traffic control	SD → 1 2 3 4 5 6 ← SA	25A
26B	SD → 1 2 3 4 5 6 ← SA	I feel that I would gladly spend the rest of my career working as an air traffic controller	SD → 1 2 3 4 5 6 ← SA	26A
27B	SD → 1 2 3 4 5 6 ← SA	I feel that I would recommend to any of my peers that air traffic control would be a great job	SD → 1 2 3 4 5 6 ← SA	27A
28B	SD → 1 2 3 4 5 6 ← SA	I feel a strong commitment to become an air traffic controller	SD → 1 2 3 4 5 6 ← SA	28A