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Development of Critical Thinking Skills in Collegiate Aviation Programs

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Critical thinking requires an individual to gather and interpret data, develop conclusions based upon relevant findings, and implement the best solution. The dynamic aviation industry requires these skills of its pilots, maintainers, and managers for companies to remain successful. Collegiate aviation programs need to teach critical thinking and cognitive skills to allow students entering the workforce to become these successful aviation managers, maintainers, and pilots. The School of Aviation at Southern Illinois University conducted a research study to inform the development of pedagogical techniques for promoting critical thinking skills in the classroom and determine their efficacy. The research study used critical thinking skills assessments, in a pre and posttest format, to determine if students experienced an increase in their ability to think critically. The findings indicate there was no statistically significant increase in students' total scores on the critical thinking assessments. However, these findings support the development of best practices which can be adopted and refined by collegiate aviation programs.

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Introduction

Statement of the Problem

Aviation-related companies find critical thinking to be a valuable skill for employees (Bhatti, 2020). The aviation industry is dynamic and requires aviation managers to adapt quickly to remain successful. Aviation managers need to, based upon trends, determine the direction the industry is heading to allow their organizations to effectively evolve and prosper. Previous research indicates the need for aviation managers to possess strong critical thinking skills but does not provide direction on how to teach critical thinking skills to students in collegiate aviation programs (Davitch & Folker, 2017). Critical thinking skills increase an individual's ability to solve problems, assess risk and make informed decisions (Bhatti, 2020).

Purpose of the Study

The purpose of the research study is to develop pedagogical techniques to promote critical thinking skills in the classroom and determine efficacy. To achieve this objective, students must be able to define critical thinking, identify specific critical thinking skills, and practice the application of these skills in the classroom. To this end, pedagogical techniques need to be developed to teach critical thinking skills to students enrolled in collegiate aviation programs.

Research Questions

1. Does the comparison of the scores on the pre-course and post-course critical thinking skills assessments indicate whether the students increased their critical thinking skills through pedagogical techniques?

2. What specific portions of the pre-course and post-course critical thinking skills assessments showed variations based upon a comparison of the scores?

Significance of the Study

Critical thinking is the ability to objectively evaluate information and develop a logical conclusion (Faruki, 2019). Aviation-related organizations find critical thinking to be a valuable skill for employees. Employees that possess critical thinking skills can solve problems, identify logical connections between ideas, evaluate arguments, and use logical reasoning to reach conclusions (Bhatti, 2020). The development of critical thinking skills amongst collegiate aviation students will likely assist these students as they pursue their careers in the aviation industry.

Assumptions & Limitations

For this study, the following limitations and assumptions are proposed:

1. This study is limited based upon the voluntary participation of two groups of collegiate aviation students asked to participate in this research study. One group consisted of collegiate aviation management students enrolled in AVM 374 General Aviation Operations course at Southern Illinois University during the fall 2021 semester. The next group consisted of collegiate aviation management students enrolled in the same course at Southern Illinois University during the spring 2022 semester. Both groups of students are pursuing a Bachelor of Science in Aviation Management at SIU. There was a low participation rate during the spring 2022 semester, so the data for both groups of students were combined for analysis.

2. This study is limited by certain uncontrollable variables that cannot be accounted for, such as student motivation, commitment, and academic aptitude.

3. It is assumed the students answered the pre-course survey and critical thinking assessment questions honestly to the best of their knowledge.

4. The same critical thinking assessment, hereafter referred to as the pretest and posttest, respectively, was used at the beginning and end of the course. The students were not able to review the pretest until they completed the posttest at the end of the semester. There was a 15-week span between the pretest and posttest given to the students. Therefore, it is assumed that students would not remember the questions when completing the posttest.

5. The critical thinking assessment (pretest and posttest) used for this research study was gathered from the Watson-Glaser critical thinking appraisal practice test, which provides validity to the critical thinking assessment used for this research study.

Literature Review

In the classroom, students absorb information in order to pass an examination, but once the examination is completed, they forget what they learned. Terenzini et al. (1993) found, “A relatively large body of evidence suggests that much of the factual material students learn during college may have a relatively short shelf-life after they leave (McLeish, 1968; Gustav, 1969; Blunt & Blizard, 1975; Brethower, 1977). It is critical to teach students how to retain that information. Several authors have defined critical thinking in various ways. According to Richard Paul, critical thinking is not a new concept. The terms “critical” and “thinking” have Greek and Latin roots. Critical thinking is described as “thinking that strives to know by judging with discernment and using standards and tests as a means” (CriticalThinkingOrg, 2015a, 7:12). Others define critical thinking differently; Richard Ennis (1993) states, "Critical thinking is reasonable reflective thinking focused on deciding what to think or do" (p. 180). Critical thinking is the ability to use intelligence, knowledge, and skills to question and carefully explore situations and arrive at thoughtful conclusions based on evidence and reason (Neck, 2016). Critical thinking is also defined as a mode of reasoning in which one improves the quality of

thought by skillfully analyzing, assessing, and reconstructing their thought processes (Davitch & Folker, 2017). Although there are numerous interpretations of critical thinking, a worldwide multidisciplinary panel defined it as "the process of conscious, self-regulating judgment" (Bycio & Allen, 2009, p. 2).

Organizations require managers who can think independently, without bias or judgment, and forecast patterns of behavior and procedures. In order to make successful and deliberate decisions, they ask the appropriate questions: how and why, rather than just what (Neck, 2016). Plummer (2019) noted most companies lack an efficient method for objectively assessing critical thinking skills and are unsure how to deliver coaching to team members who need to improve their critical thinking abilities. The ability to think critically and problem-solving requires the ability to think fundamentally and systemically, particularly in the context of problem-solving (Cahyo et al., 2020). The business world requires individuals with excellent communication skills, the ability to work in teams, and problem-solving abilities. The ability to solve problems is a high-level cognitive ability (Cahyo et al., 2020). Belkin (2017) noted test results from exams administered between 2013 and 2016 indicated that the typical graduate showed little or no progress in critical thinking across four years at universities.

Companies have been using pre-employment testing to determine which applicant is a good fit for the organization. One of the skills that businesses look for in employees is the ability to identify solutions to challenges. Employers place a high value on the ability to provide a well-thought-out solution in a fair amount of time. Other organizations seek people who can perform tasks beyond reading, writing, and math, such as critical thinking and problem-solving. Companies/organizations might expect a distinct level of corporate culture if they have the ability to use critically improved thinking. In the long run, improved culture may convert into money or more income, but in the near run, it may translate into enhanced personal communications, cooperation, and collaboration (Murawski, 2014).

Management needs employees who can make decisions with minimal supervision, allowing them to make decisions on their own ("What is the RED Model," 2019). Kuncel and Hezlett (2010) made the following observation: Numerous research studies were undertaken in both educational and employment settings to examine if cognitive assessments predict performance. The findings were inconsistent, with some research claiming that cognitive test scores are virtually perfect indicators of performance and others claiming that cognitive test scores are unrelated to academic and professional achievement. According to Belkin (2017), a PayScale Inc. poll indicated that 50% of employers say college graduates they recruit are not ready for the profession, with weak critical-reasoning abilities being the most common complaint. In fact, Belkin reports 60% of managers saying that recent graduates lack critical thinking skills (Belkin, 2017).

Ennis (1993) stated there are many critical thinking examinations; however, he found no subject-specific categorization in the collection of critical thinking tests. Existing multiple-choice tests do not appropriately examine several crucial aspects of critical thinking, such as being open-minded and cautiously reaching justified conclusions. The critical thinking essay test is an anomaly; it covers more ground than the others, but it is less secure and requires more time and money than multiple-choice examinations. Using the Watson-Glaser test, Daryl Smith (1977) discovered that increased praise, peer-to-peer connection, and student participation lead

to more high-critical-thinking behaviors. Furthermore, as these processes become more prevalent, memorization habits become less prevalent. Watson and Glaser identified five critical-thinking skills: inference, assumption recognition, deduction, interpretation, and argument evaluation. The Watson-Glaser Critical Thinking Appraisal (WGCTA) proved to be the most effective tool for evaluating hypotheses and research questions (Stone, 2016). The WGCTA is designed to measure those important abilities and skills involved in critical thinking (WGCTA, 2012). Robert Ennis's view on most critical thinking tests is that they are not comprehensive, especially those that are easiest to use, such as the multiple-choice tests (Ennis, 1993). Critical thinking skills should be measured over time, just as instructor pilots conduct periodic check rides for their students (Davitch et al., 2017, p. 63). The WGCTA has been used to predict performance in a variety of educational settings (Ejiogu et al., 2006). Recent research "finds that cognitive aptitude tests, particularly critical thinking exams, ... are among the strongest and most consistent predictors of success across academic and work settings" (Neck, 2016, p. 1). Critical Thinking Competency Standards provide a framework for assessing students' critical thinking abilities. It enables administrators, teachers, and faculty at all levels to determine the extent to which students are reasoning critically within any subject or discipline (Paul & Elder, 2005).

Currently, there is a scarcity of research on methods for building important abilities in potential pilots. The business world requires individuals with excellent communication skills, the ability to work in teams, and problem-solving abilities. The ability to solve problems is a high-level cognitive ability (Cahyo et al., 2020). The link between critical thinking and problem-solving abilities is also vital for aviation mechanics in the field. Critical thinking is a talent that is frequently required in aircraft repair. This expertise is vital since aircraft technicians are often confronted with troubleshooting issues. Mechanics must draft and retain repair records, as well as document all preventative and corrective maintenance on the aircraft (Cahyo et al., 2020).

A study done by Herasymenko et al. (2019) on aviation studies found that the "education system in flying institutions did not" appear to "focus on Aviation English as a tool for developing critical thinking skills (Herasymenko et al., 2019, p. 100). These researchers emphasized the link between critical thinking abilities and linguistic ability. They acknowledge that programs focused on strengthening critical thinking can improve language abilities. Incorporating critical thinking exercises into the core of the Aviation English course can result in improved aviation safety (Herasymenko et al., 2019).

In the introduction of Richard Paul's lecture on "How to teach students to listen and read properly," listening and reading are only effective learning tools when done correctly, yet most students are deficient in elementary listening and reading skills (CriticalThinkingOrg, 2015b). The essential goal in education should be to advance students' ability to think critically (Trapasso, 2021). The ability to think critically and to solve problems leads to the ability to think fundamentally and systemically, particularly in the context of problem-solving (Cahyo et al., 2020). Adam Stone (2017) discovered the need to find instructors with good critical thinking scores to teach critical thinking, as students mirror their instructors' critical thinking scores. Stone noted research done by Lois Magnussen on a nursing program suggests those students with low scores improved to approximate the teachers' critical thinking scores, while students with previously similar scores with the instructor have remained nearly the same. Nursing students

with high critical thinking scores plummeted to average scores over the course of the multiyear program (Stone, 2017). An analysis from Huber and Kuncel (2016) found nursing students simply did not improve more than their non-nursing counterparts. For other specialties, it is unknown if critical thinking grows linearly or more rapidly throughout the college years (Huber & Kuncel, 2016).

To be successful in the aviation sector, pilots, mechanics, and management must be able to think critically. Research has found students study for the exam and forget what they learned shortly after graduation. Management in the aviation industry feels new graduates lack critical thinking and problem-solving skills. Acquiring those skills is vital in higher education, yet there is evidence that some students have shown little progress in critical thinking after four years of study. To improve students' ability to think critically, it was found through research that hiring teachers with great critical thinking abilities would increase a student's critical thinking skills to the same level as the instructor's scores. A range of assessments, practice, hands-on repetition and feedback have been found to increase students' critical thinking skills. In exchange, students need to become lifelong learners and commit to the continual improvement of their critical thinking skills.

Methodology

Research Design

This study is based upon applied research and focuses on the development of critical thinking skills within the classroom and the performance of students completing critical thinking assessments used to validate an improvement in critical thinking skills.

Once data collection and analysis were complete, the researchers were able to determine if the critical thinking materials and exercises provided in class were effective at increasing students' critical thinking skills. It is assumed that higher scores on the posttest indicate an increase in participants' critical thinking skills. Only then can pedagogical techniques be developed and evaluated to teach critical thinking skills to students enrolled in collegiate aviation programs.

A mixed methodology approach was used for data collection, as the researchers applied quantitative and qualitative inquiry during the research study. There is a need for the hard data that quantitative research provides; however, the soft data that qualitative analysis provides fills the gaps left by quantitative data or provides needed context (Patton, 2015). Combining the two research methods allowed the researchers to develop accurate and comprehensive conclusions. The purpose of the mixed method approach was to determine the efficacy of pedagogical techniques to increase critical thinking skills.

Target Population and Participant Selection

This research used purposeful sampling. Purposeful sampling focuses on a smaller sample to allow for a comprehensive analysis rather than a larger sample which provides a cursory investigation (Patton, 2015). Both qualitative and quantitative inquiry was used to

collect data. This study focused on depth by using a smaller sample size. The sample size was influenced by several factors, such as lack of compensation for participants and voluntary participation. There was no compensation provided for students to participate in the study, which may have discouraged participation. Also, participation was voluntary as the pretest and posttest scores were not part of students' course grades. This impacted students' commitment to complete both assessments as some students completed the pretest at the beginning of the semester but chose not to complete the posttest at the end of the semester. Despite the small sample size, sufficient data was collected, and meaningful conclusions were reached. Data were collected from two groups of students. Two groups of students were enrolled in the AVM 374: General Aviation Operations course, using a traditional 16-week format, during the Fall 2021 and Spring 2022 semesters.

Participants

The critical thinking skills of 27 students in the SIU School of Aviation were assessed. Seven students were eliminated from the study because of incomplete data (either did not take the pretest or posttest), leaving 20 participants with sufficient data for analysis. The participants were 70% male and 30% female, with a mean age of 22.6 years. 65% of participants identified as White, 15% as Hispanic, 10% as Black, and 10% as Other. The mean GPA for the participants was 3.42, with 3.2 being the mode GPA of the participants. Ten percent of the students were sophomores, and 45% were juniors and seniors.

Procedures

Eighteen (n=18) students during the fall 2021 semester and nine (n=9) students during the spring 2022 semester participated in the research study. However, only two (n=2) of the spring 2022 students completed the research study by completing the posttest leaving a total of 20 participants with sufficient data for analysis. The students completed the pretest during the first week of class and completed the posttest on the last day of class. All the students who participated during the fall 2021 semester completed the posttest, but seven of the students during the spring 2022 semester did not complete the posttest.

The critical thinking measure was administered at the beginning of the semester and at the end of the semester to explore possible changes to students' critical thinking skills as a result of participation in the course. The Watson-Glaser Critical Thinking Appraisal is the most commonly used psychometric test by organizations for the pre-selection of managers (Pearson, n.d.). Participants' critical thinking skills were assessed using the Watson-Glaser Critical Thinking Appraisal in a pretest, posttest research design. The Watson-Glaser Critical Thinking Appraisal uses the RED model, which organizes critical thinking based on the ability to recognize assumptions, evaluate arguments, and draw conclusions (Pearson, n.d.). Studies have indicated a positive correlation between those individuals that score well on the Watson-Glaser Critical Thinking Appraisal and job and course success (Pearson, n.d.).

Data Collection

The qualitative data from the research study was collected through the student pre-course survey, which provided a great deal of qualitative data about the students that could not be realized through the pretest and posttest. Specifically, the student pre-course survey collected information such as demographics, educational history, and other pertinent information. The qualitative data was analyzed to illuminate the quantitative data. Without this valuable qualitative data, the quantitative data gathered from the student pretests and posttests stands as it is yet to provide little understanding. Analyzing the quantitative data through the lens of qualitative data allowed the researchers to provide credible answers to the research questions.

Research Instruments

The student pre-course survey consisted of 10 closed and seven open-ended questions for a total of 17 questions. The pre-course survey collected demographic data and assessed the participants' opinions and interest in critical thinking skills

The pretest and posttest data were collected based upon 83 questions organized within the following sections: (1) inferences – 16 questions, (2) assumptions – 20 questions, (3) deduction – 16 questions, (4) interpretation – 15 questions, and (5) evaluating arguments – 16 questions. As stated previously, the pretest and posttest were the same; however, students were unable to review their pretest results until after they completed the posttest.

Students completed two cognitive tests throughout the semester. The first cognitive test measured students' ability to use abstract reasoning skills, and the second cognitive test measured students' ability to employ inductive reasoning skills. The purpose of the cognitive tests was to introduce students to these tests and increase their ability to use abstract and inductive reasoning skills. These same cognitive tests were not administered a second time to determine if there was an increase in students' cognitive skills.

Next, throughout the semester, the students worked in groups to conduct an analysis of the Boeing 737 MAX case. Students were tasked to begin the analysis by gathering the facts of the case. Next, the students conducted an in-depth analysis of the facts and identified the core realities of the case. The students started this exercise with a factual maze because the information was unstructured and lacked order. Students needed to focus on themes and narratives that were supported by facts instead of seizing upon themes and narratives that seemed appealing, then selecting facts to support them (Faruki, 2019). Students were required to use tools such as timelines and t-charts to assist with organizing the facts. The exercise culminated with each group of students providing a S.A.I.S.I. (Situation as I see it) response to the Boeing 737 MAX case (Faruki, 2019).

Games and activities were provided throughout the semester to develop students' critical thinking skills. These games and activities facilitated the students' abilities to determine fact from opinion, think "outside of the box" to develop unique solutions and many more important skills.

Finally, throughout the semester, all students were provided with content regarding critical thinking skills. The content was provided via PowerPoint presentations. The researchers developed an adaptable curriculum that, while providing important critical thinking content, could be woven into the existing curriculum of an existing collegiate aviation course. Part one of the curriculum provided a general overview of critical thinking. The general overview portion provided the following content: (1) a definition of critical thinking, (2) the reasons why critical thinking is important, (3) critical thinking assessments used by employers, and (4) critical thinking and the aviation industry.

Part two explained the critical thinking process and introduced higher-order thinking skills (HOTS). Part two provided the following content: (1) five components of critical thinking, (2) a definition of HOTS, and (3) Bloom's taxonomy. Part three introduced the following concepts: (1) the RED model, (2) the definition of inference, and (3) the steps to recognize and develop an inference. Part four delivered the content regarding (1) the definition of assumptions, (2) two types of assumptions, (3) identifying assumptions within an argument, and (4) inference versus an assumption. Part five introduced the concept of deduction: (1) definition of deduction, (2) evaluation of deductions, (3) deduction equation, and (4) inductive versus deductive reasoning. Part six delivered content regarding interpretation: (1) definition of interpretation and (2) interpretation versus inference. Finally, part seven provided content regarding the evaluation of arguments: (1) the strength of an argument and (2) argumentative fallacies.

Data Analyses

Data for the 20 participants were entered and cleaned in Microsoft Excel and were subsequently imported into IBM SPSS for statistical analysis. A paired samples t-test was selected to analyze the pre-post data. Tests for normality were conducted; skewness and kurtosis were observed, Q-Q plots and Box plots were used to observe outliers. The Shapiro-Wilk test was chosen to test normality because our sample size was less than 50. The data for Inferences, Interpretation, and Total Score were normally distributed. Data for Assumptions, Deduction and Evaluation of Arguments were not normally distributed. Therefore a non-parametric test, Wilcoxon Signed-Ranks Test, was performed to further evaluate the results of the paired samples t-test.

The mixed methodology approach was used for this research study. The data analysis consisted of three phases: (1) analysis of the quantitative data, (2) analysis of the qualitative data, and (3) analysis of how the qualitative data explains the qualitative data. This qualitative data is needed to explain the quantitative data collected through the pre and posttests. The quantitative data demonstrates how each group of students performed, but the qualitative data helps to answer the question of why these students performed as they did. The two research questions for this study were addressed using quantitative data collected from students' grades on the pre and posttests. The quantitative data was supplemented by qualitative data gathered from the student pre-course surveys. The qualitative data was used to identify patterns and opinions that could explain the results from the quantitative data (Empower, n.d.).

Results

The findings of the research study were analyzed to determine if collegiate aviation students can increase their critical thinking skills through pedagogical techniques used within the classroom.

Quantitative Results

To evaluate the critical thinking skills of 20 participants in the study, after participating in the AVM 374: General Aviation Operations course, the variable pre-post difference data were analyzed for normality. Issues with skew and kurtosis were observed for; Deduction (skew, -1.71 and kurtosis 6.14), indicating a negative skew and leptokurtic tendency. Evaluation of Arguments had a kurtosis 4.18, also indicating a leptokurtic tendency, while Total Score difference data indicated a platykurtic tendency (kurtosis -.26).

A Shapiro-Wilk test was conducted to assess normality. Shapiro-Wilk results showed that the data distribution of the Assumptions ($W = .885$, $p < 0.02$), Deduction ($W = .841$, $p < .004$), and Evaluation of Argument ($W = .882$, $p < .019$) departed significantly from normality (See Table 1 below). Based on these results, a non-parametric test was conducted to confirm the results of the paired samples t-test.

Table 1
Shapiro-Wilk Test of Normality Using Mean Differences

	Shapiro-Wilk		
	Statistic	df	Sig.
Inference	.968	20	.703
Assumptions	.885	20	**.022**
Deduction	.841	20	**.004**
Interpretation	.925	20	.123
Evaluation of Argument	.882	20	**.019**
Total Score	.969	20	.733

Paired samples t-tests were conducted on the critical thinking pretest and posttest data for each variable. The Inference mean on the pretest was 39.05 (SD = 12.25), and the mean on the Inference posttest was 32.35 (SD = 9.18). A significant difference was found between the pretest and the posttest, $t(19) = 2.21$, $p = .039$, CI [.36, 13.03]. Significant differences in the pretest and posttest scores were not found for; Assumptions pretest M=65.50, SD=20.38, posttest M=61.25, SD=18.62, $t(19) = 1.00$, $p = .326$. CI [-4.58, 13.08]; Deduction pre-test M=74.55, SD=19.59, posttest M=79.30, SD=15.94, $t(19) = -.847$, $p = .407$, CI [-16.48, 6.98]; Interpretation pre-test M=68.10, SD=20.38, posttest M=71.45, SD=15.35, $t(19) = -.756$, $p = .459$. CI [-12.62, 5.92]; Evaluating Arguments pre-test M=60.75, SD=19.68, posttest M=56.60, SD=19.48, $t(19) = .909$, $p = .375$. CI [-5.40, 13.70]; and Total Score pre-test M=61.60, SD=10.65, posttest M=59.80, SD=11.38, $t(19) = .923$, $p = .368$, CI [-2.28, 5.88].

Table 2
Pair Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Inferences T1	39.0500	20	12.25808	2.74099
	Inferences T2	32.3500	20	9.18967	2.05487
Pair 2	Assumptions T1	65.5000	20	20.38446	4.55810
	Assumptions T2	61.2500	20	18.62900	4.16557
Pair 3	Deduction T1	74.5500	20	19.59451	4.38147
	Deductions T2	79.3000	20	15.94101	3.56452
Pair 4	Interpretation T1	68.1000	20	20.38291	4.55776
	Interpretation T2	71.4500	20	15.35021	3.43241
Pair 5	Evaluating Arguments T1	60.7500	20	19.68936	4.40268
	Evaluating Arguments T2	56.6000	20	19.48657	4.35733
Pair 6	Total Score T1	61.6000	20	10.65932	2.38350
	Total Score T2	59.8000	20	11.38605	2.54600

Table 3
Paired Samples t-Test Results

	Paired Differences							Significance	
				95% Confidence Interval of the Difference					
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Inferences	6.700	13.530	3.025	0.368	13.032	2.215	19	0.020	**0.039**
Assumptions	4.250	18.868	4.219	-4.580	13.080	1.007	19	0.163	0.326
Deduction	-4.750	25.066	5.605	-16.481	6.981	-0.847	19	0.204	0.407
Interpretation	-3.350	19.824	4.433	-12.628	5.928	-0.756	19	0.230	0.459
Evaluating Arguments	4.150	20.423	4.567	-5.408	13.708	0.909	19	0.187	0.375
Total Score	1.800	8.721	1.950	-2.282	5.882	0.923	19	0.184	0.368

Due to violations of the assumptions of normality in the data, a Wilcoxon Signed-Ranks Test for related samples was also conducted. The results indicated that posttest scores on for critical thinking skill, Inference, were significantly lower than pretest Inference scores on the pretest (T = 36.50, z = -2.14, p = .032) (See Wilcoxon Signed Ranks Test data in Table 4 below), indicating that the median posttest ranks, Mdn = 31.00 were statistically lower than the pretest ranks, Mdn = 38.00. Statistical significance was not found for the remaining variables; Assumptions, pretest Mdn = 75.00, posttest Mdn = 67.50 (T = 50.00, z = -.910, p = .362); Deduction, pretest Mdn = 75.00, posttest Mdn = 88.00, (T = 90.00, z = -.641, p = .522); Interpretation, pretest Mdn = 67.00, posttest Mdn = 80.00, (T = 100.00, z = .636, p = .525); Evaluating Arguments, pretest Mdn = 69.00, posttest Mdn = 63.00, (T = 45.00, z = -1.19, p

= .232) ; and Total Score, pretest Mdn = 61.50, posttest Mdn = 65.00, (T = 62.50, z = -1.005, p = .315).

Table 4
Related-Samples Wilcoxon Signed Rank Test Summary

Variable	Total N	Test Statistic	Standard Error	Standardized Test Statistic	Asymptotic Sig (2-sided)
Inferences	**20**	**36.5**	**22.86**	**-2.14**	**0.032**
Assumptions	20	50.5	19.18	-0.91	0.362
Deduction	20	90	21.07	0.641	0.522
Interpretation	20	100	22.78	0.636	0.525
Evaluating Arguments	20	45	19.24	-1.19	0.232
Total Score	20	62.5	22.89	-1.005	0.315

The results of the Related Samples Wilcoxon Signed Rank test supported the results of the paired samples t-test, indicating that Inferences was the only variable to show a significant change in students' test scores between the pretest and posttest administrations of the Watson-Glaser Critical Thinking Appraisal. The results indicate that students' scores were significantly lower on the posttest than on the pretest. Although there were mean increases in posttest scores for Deduction and Interpretation, the differences were not statistically significant. Additionally, no statistically significant differences in student scores were detected for Assumptions, Evaluating Arguments, or for students' Total Score on the assessment (See Table 7 below). Implications of these findings are addressed in the discussion section. There were no correlations between the demographic data and the test scores on the measure that was meaningfully significant.

Demographic Questions and Qualitative Data – Pre-Course Survey

The demographic data for gender, age, ethnicity, GPA, and academic status were provided in the participants' section. However, some demographic data was not sufficient for statistical analysis due to several factors. The students were homogenous regarding age and the highest level of education. There was not enough diversity in ethnicity or gender to lead to any meaningful statistical analysis. The graduation date was not included because the students could not accurately provide this information for the research study. Finally, there were no individuals who had military experience, and few had received academic scholarships, so this data was removed from the data analysis.

Open-Ended Questions – Pre-Course Survey

In addition to the demographic questions, this research study was designed to collect informative qualitative data using open-ended questions in the pre-course student survey. The open-ended questions sought information that would provide the researcher with the level of interest the students had in the course and the development of critical thinking skills. Next, the

questions sought information to indicate if the students thought critical thinking skills would be useful in their careers. The final questions of the pre-course survey focused on students' career goals in the aviation industry, as well as students' interest in pursuing a graduate degree in the future.

The researchers manually coded and compared all the students' responses from the pre-course student surveys to identify commonalities among responses. Next, the researchers clustered all the students' responses into common themes (Creswell & Creswell, 2018). From the data collection and analysis, conclusions and recommendations were identified.

Student Responses – Pre-Course Survey Question 11

The first open-ended question in the pre-course student survey (Q11) sought to determine students' level of interest in the development of critical thinking skills. The researcher used a four-point scale to quantify the responses to (Q11). The scale was used to quantify the level of interest students have in the development of critical thinking skills. The four-point scale was assigned numerical values: (1) Very interested, (2) Moderate interest, (3) Neutral, and (4) No interest. Forty-four percent of participants indicated they were very interested in the development of critical thinking skills. Respectively, 30% and 26% of students possessed a moderate interest or were neutral regarding their interest. Almost three quarters of the participants indicated a high to moderate level of interest in the development of critical thinking skills.

Student Responses – Pre-Course Survey Question 12

The second open-ended question in the pre-course student survey (Q12) identified students who have received any critical thinking training. If the student had received critical thinking training, they were asked to indicate when and the type of training they received. Only two students indicated they had received critical thinking training, which did not provide adequate data to lead to any meaningful statistical analysis.

Student Responses – Pre-Course Survey Question 13

The third open-ended question in the pre-course student survey (Q13) sought to determine if the students thought critical thinking skills would be useful in their careers. Common themes that emerged from student responses to Q 13: (1) many students valued critical thinking skills because they assist with problem-solving and decision-making, and (2) students perceived value in critical thinking skills when pursuing a career as a pilot, airport operations specialist, or management position.

Student Responses – Pre-Course Survey Question 14

The purpose of the fourth open-ended question in the pre-course student survey (Q14) was to identify the students who planned to pursue a career in the aviation industry. Prevalent points that emerged from student responses to Q14: (1) several students indicated the desire to pursue a career as an air traffic controller, (2) four students intend to pursue a career in airport

management or another aviation-related management position, (3) five students have not decided upon one career opportunity within the aviation industry and listed several options, and (4) the majority of students intend to pursue a career as a pilot.

Student Responses – Pre-Course Survey Question 15

The fifth open-ended question in the pre-course student survey (Q15) identified students who are currently employed in the aviation industry. Only four students indicated they were employed in the aviation industry, which did not provide adequate data to lead to any meaningful statistical analysis.

Student Responses – Pre-Course Survey Question 16

The goal of the sixth open-ended question in the pre-course student survey (Q16) was to identify the specific career and professional goals of the students. Common professional goals that emerged from student responses to Q16: (1) several students intend to pursue a career in airport management, air traffic control, or another aviation-related management position, but (2) the majority of students intend to pursue a career as a pilot.

Student Responses – Pre-Course Survey Question 17

The final open-ended question in the pre-course student survey (Q17) asked students if they planned to pursue a graduate degree. The student responses to Q17 indicate: (1) approximately half of the students are considering or intend to pursue a graduate degree, and (2) most of the students indicate an interest in pursuing an aviation-related graduate degree.

Conclusions

The purpose of the research study is to develop techniques to promote critical thinking skills in the classroom and determine efficacy. To achieve this objective, students must be able to define critical thinking, identify specific critical thinking skills, and apply these skills within the aviation industry. To this end, pedagogical techniques need to be developed to teach critical thinking skills to students enrolled in collegiate aviation programs.

Conclusions Based on Research Question 1 (RQ1)

The first research question (RQ1) stated, "Can collegiate aviation students increase their critical thinking skills through pedagogical techniques used within the classroom as demonstrated by the achievement of higher scores on the post-course critical thinking skills assessment than on the pre-course critical thinking skills assessment?" The test scores for the inference section were the only section to show a significant change in students' test scores. The results indicate the students' scores were significantly lower on the posttest than on the pretest. Although there was an increase in the average test scores for the deduction and interpretation sections, the differences were not statistically significant. The statistical analysis indicated there was no statistically significant difference in the pretest and posttest scores for the assumption, and evaluation of arguments sections of the test. More important, there was no statistically

significant difference between students' total scores on the pretest and posttest. Therefore, the use of pedagogical techniques within the classroom for this research study did not provide an increase in the students' critical thinking skills. It is assumed that students will earn higher total scores on the posttest if they experience an increase in their critical thinking skills.

Conclusions Based on Research Question 2 (RQ2)

The second research question (RQ2) stated, "Did the collegiate aviation students achieve higher scores on specific portions of the post-course critical thinking skills assessment to identify specific critical thinking skills students were able to develop because of the pedagogical techniques used in the classroom?" Students average pretest scores (M = 74.55) and posttest scores (M = 79.3) in the deduction section of the test indicated a small increase of 4.75 points. Likewise, students' average pretest scores (M = 68.1) and posttest scores (M = 71.45) in the interpretation section of the test indicated a small increase of 3.35 points. These findings indicate there may have been a modest increase in the students' critical thinking skills due to the pedagogical techniques used in the classroom.

Recommendations

Based on the findings and conclusions of this research study, the following recommendations have been formulated:

Although there was no finding of significant statistical differences between the pretest and posttest final scores, the scores on the inferences portion of the posttest showed a significant decline. Several factors require analysis as they may inform researchers of the reasons for the decline in the inferences test scores. First, learning to make inferences is one of the most difficult critical thinking skills to acquire because students are required to "read between the lines." (how2become, 2017). When making inferences, students must arrive at a conclusion that is not explicit but is implied based on the evidence. Next, inferences are similar to interpretations and can be easily confused. Interpretations require students to determine if a conclusion logically follows a statement (how2become, 2017). An inference is a conclusion that is reached based on facts and students are required to determine the probability of the inferences, based upon the facts, being true or false. The students cannot answer yes or no. Instead, they need to determine probability. In the inferences portion of the assessment, students were given the following options to select from: (1) definitely true; (2) probably true; (3) insufficient data to say whether it is true or false; (4) probably false; and (5) definitely false. The pedagogical techniques used within the classroom to instruct students on how to make inferences caused confusion. The students had difficulty differentiating between assumptions, interpretations, and inferences which may have contributed to the lower posttest scores on the inferences portion of the posttest. The portion of the critical thinking lecture that addresses inferences needs to be revised to provide clarity. Furthermore, more effective in-class activities need to be implemented that will enable the students to make accurate inferences.

This research study was limited by several uncontrollable variables, such as student motivation, commitment, and academic aptitude. With that being said, student motivation and commitment may have been significant factors that influenced the pretest and posttest scores.

The scores on the critical thinking skills assessments, along with the in-class activities associated with this research study, were not part of students' grades for the course. Also, the critical thinking material provided during class lectures was not included in any of the course assessments (quizzes and final examinations). These facts may have had a significant impact on the motivation of the students to complete the pretest and posttest to the best of their ability. A solution may be to include critical thinking materials covered during the lectures in the course assessments. In this case, students may have an increased commitment to learning the critical thinking material. Also, some of the in-class activities that were part of this research study could be included as part of the overall grade for the course, which could result in increased student commitment and motivation.

It was assumed the students would answer the pre-course survey and critical thinking skills assessment questions to the best of their ability. It is likely the students completed the pre-course survey and critical thinking skills assessment to the best of their ability; however, this may not have been the case when completing the post-course critical thinking skills assessment. The post-course critical thinking skills assessment was administered at the end of class on the last day of the course. Many students were eager to leave as it was the last day of the course. This may have impacted the amount of effort the students expended when completing the posttest. It is likely the students rushed through the posttest so they could leave class quickly. To resolve this issue, the posttest should be administered in class two weeks prior to the end of the semester.

Concluding Remarks

Although there were no statistically significant differences in the students' total scores on the pretest and posttests, research needs to continue to establish effective pedagogical techniques to increase critical thinking skills for students enrolled in collegiate aviation programs. The aviation industry will continue to place a high value on those employees that possess these critical skills. Aviation will continue to evolve rapidly, and critical thinkers are needed to help aviation companies adapt and prosper. The aviation managers, maintenance technicians, and pilots of the future must possess fundamental critical thinking skills. This research study provides preliminary findings that will assist collegiate aviation programs in developing pedagogical techniques that will be effective for their program. Further research is needed to determine the efficacy of various pedagogical techniques. The findings will support the development of best practices which can be adopted and refined by collegiate aviation programs.

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