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International Journal of Aviation, Aeronautics, and Aerospace

Volume 10 | Issue 2 Article 6

2023

Evaluating the Effects of Safety Management Systems (SMS) on Safety Culture Factors in Collegiate Aviation Operations: A Structural Equation Modeling (SEM) Approach

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Scholarly Commons Citation
Foster, R. A., & Adjekum, D. K. (2023). Evaluating the Effects of Safety Management Systems (SMS) on Safety Culture Factors in Collegiate Aviation Operations: A Structural Equation Modeling (SEM) Approach. *International Journal of Aviation, Aeronautics, and Aerospace, 10*(2). DOI: https://doi.org/10.58940/2374-6793.1788

Collegiate aviation operations in the United States, as compared to commercial airline operations, are characterized by an environment of low levels of experience among trainee pilots, varying training course outline complexities, high potential for accidents due to training intensity, and rigorous certification standards for airmen (Adjekum, 2014; Freiwald et al., 2013; National Transportation Safety Board [NTSB], 2019).

Collegiate aviation also faces some unique challenges concerning the sustenance of a proactive safety culture due to the limited tenure of students and recurrent turn-over of certified flight instructors (CFI) within the program, which can impact safety cultural acclimatization and retention of institutional memory (Adjekum, 2017; von Thaden, 2008). In addition, the unique demography of collegiate aviation students and CFI also provides psycho-social factors predisposing them to increased risk-taking (Keller et al., 2021; Reason, 2008; von Thaden, 2008).

Numerous studies have explored safety culture in various industries, including aviation, and have emphasized the importance of a systematic approach to safety management (Adjekum, 2014, 2017; Gill & Shergill, 2004; McDonald et al., 2000; Remawi et al., 2011; Chen & Chen, 2012; Patanker & Sabin, 2010; Robertson, 2018; Stolzer et al., 2018).

Part of this systematic approach to safety is the increasing acceptance and implementation of Safety Management Systems (SMS) in aviation operations. SMS is a systematic approach to managing safety, including the necessary organizational structures, accountability, responsibilities, policies, and procedures (International Civil Aviation Organization [ICAO], 2018).

While SMS implementation is not currently mandatory for collegiate aviation programs, some universities have implemented SMS preemptively (Pinholster, 2019). As part of the implementation process, some validated measurement models to assess the relationship between SMS implementation and safety culture in collegiate aviation programs have been developed (Adjekum, 2016, 2017; Robertson, 2018).

In a study of SMS and safety culture in collegiate aviation, Adjekum (2017) derived two factors underlying the latent construct of SMS initiative: SMS policy implementation (SMS Pol) and SMS process engagement (SMS Pro). Adjekum (2017) further proposed a measurement model to assess the relationships between SMS initiative, transformational safety leadership, self-efficacy, and the outcome variable safety behavior measured by safety compliance (SC) and safety participation (SP) and a mediator safety motivation (SM).

In defining the variable, SMS Pol referred to the organization's leadership's policy framework that guides implementation practices and strategies to ensure the SMS initiative's effectiveness. SMS Pro referred to the degree of involvement and acceptance by organizational personnel of the SMS processes. SC referred to activities that need to occur to exist for a safe work environment, and SP referred to voluntary activities that may enhance safety but are not considered to have the same direct effects that safety compliance has on a safe working environment (Griffin & Neal, 2000).

The mediator SM was defined as "…the extent to which individuals viewed safety as an important part of their work-life" (Neal & Griffin, 2006, p. 948). Extant studies have also explored the role of safety motivation as a primer for safety behavior. For example, Griffin and Neal (2000) argued that safety performance is determined by how motivated individuals are to perform the related safety behavior.

SM has also been suggested as a mediator in understanding the related psychological paths between generic organizational practices and specific safety behaviors (Chen & Chen, 2014). Safety motivation is positively related to safety compliance and participation (Caesens & Brison, 2023; Chen & Chen, 2014; Christian et al., 2009; Neal & Griffin, 2006).

The studies on the measurement models that assess the relationship between SMS and safety culture in collegiate aviation focused on one type of SMS initiative. This has created a gap in the research to refine these measurement models further using data derived from different types of SMS initiatives and a more diverse collegiate aviation sample to evaluate its effectiveness. It is also expedient to determine how different SMS initiatives affect safety culture perceptions in collegiate aviation programs.

In a recent study, Hong et al. (2022) investigated safety culture perceptions at pilot training schools in Texas, the US, and Korea. The authors examine the differences in perceptions of safety culture between pilot training schools in the USA and South Korea and how these differences affect the organizations.

Hong et al. (2022) suggest that a pilot training school must have a well-defined safety culture and safety management procedures in place that creates an awareness of the diverse cultural backgrounds of its student pilots. That helps to avoid potential cultural clashes and needless accidents/incidents in collegiate aviation. As with previous studies (Adjekum, 2014, 2017), Hong et al., 2022 recommended further studies to explore the effects of demographic variables such as international and domestic student status on the perceptions of safety culture.

Purpose of the Study

This research aimed to follow up on recommendations from Adjekum (2014, 2017) and Robertson (2018) for assessments of safety culture perceptions across multiple universities with varying levels and types of SMS implementation.

In addition, the effectiveness of a hypothesized measurement model for assessing the relationships between SMS, SM, and safety culture components was assessed using data from samples drawn from diverse collegiate aviation programs implementing various types of SMS.

The exogenous variables in the hypothesized model were SMS Pol and SMS Pro, and SM as a mediator. The behavioral components of safety behavior, SP and SC, were the endogenous variables. In addition, another behavioral component in the form of a safety reporting (SR) scale was included as an endogenous variable based on items from the Collegiate Aviation Perception of Safety Culture Assessment Scale (CAPSCAS) developed by Adjekum et al. (2015, 2016).

The theoretical underpinnings for the behavioral components of safety culture are grounded in the Theory of Planned Behavior (TPB), which conceptualize perceived behavioral control to account for factors outside the individual's control that may affect one's intention and behavior (Ajzen, 1991).

Another theoretical basis is the Social Exchange Theory (SET) which postulates a cost-benefit mutual relationship between two parties in any organization (Hofmann et al., 2003; Wishart et al., 2019). Under the SET, personnel perceive personal commitment to safety reporting as a civic responsibility, while management also has a corporate and social responsibility to provide expeditious feedback and responses for action taken on these reports (Curcuruto & Griffin, 2018).

Finally, this study assessed how various demographical variables, such as international or domestic student status affected perceptions of safety behavior (SC & SP) and SR in collegiate aviation programs in various stages of SMS implementation and using varying types of SMS initiatives.

Research Questions

The research questions highlighted below explore hypothesized relationships between SMS factors, SC, SP, SR, and the mediation variable SM:

1. What are the strengths of the hypothesized relationship between SMS process engagement, SMS policy implementation, and safety behavior measured by safety compliance and safety participation, and safety reporting behavior across multiple collegiate aviation programs when mediated by safety motivation?
2. What are the differences in perceptions of safety behavior and safety reporting per demographic variables (year group, international student status, SMS status, and flight certification) across multiple universities with collegiate aviation programs?

Statement of Hypotheses

SMS Process Engagement, Safety Motivation, Safety Behavior, and Safety Reporting

The SMS process engagement scale is directed toward assessing the extent to which, in collegiate aviation, students and flight instructors are included or engaged with SMS processes. This is meant to provide a sense of "buy-in" from the frontline individuals.

This sense of involvement or engagement is related to overall favorable perceptions of safety culture based on such behavioral engagement (Adjekum et al., 2016; Chiu et al., 2019). The hypothesized relationships between SMS process engagement, safety motivation, safety behavior, and safety reporting are:

H_1: Respondents' perceptions of their collegiate aviation program's SMS process engagement are related to their safety motivation.

H_2: Respondents' perceptions of their collegiate aviation program's SMS process engagement are related to their safety compliance.

H_3: Respondents' perceptions of their collegiate aviation program's SMS process engagement are related to their safety participation.

H_4: Respondents' perceptions of their collegiate aviation program's SMS process engagement are related to their safety reporting.

H_5: Respondents' safety motivation mediates the relationship between their perceptions of their collegiate SMS process engagement and safety compliance.

H_6: Respondents' safety motivation mediates the relationship between their perceptions of their collegiate SMS process engagement and safety participation.

H_7: Respondents' safety motivation mediates the relationship between their perceptions of their collegiate SMS process engagement and safety reporting.

SMS Policy Implementation, Safety Motivation, Safety Behavior, and Safety Reporting

SMS policy implementation deals with the importance of a clearly articulated SMS policy where roles, responsibilities, authorities, and communication lines are established. Additionally, it supports the importance of having backing from top-level personnel, which is regarded as a fundamental component of SMS (FAA, n.d., 2015a, 2019; ICAO, 2009; Stolzer & Goglia, 2016). The hypothesized relationships between SMS policy implementation, safety motivation, and safety behavioral components are:

H_8: Respondents' perceptions of their collegiate aviation program's SMS policy implementation are related to their safety motivation.

H_9: Respondents' perceptions of their collegiate aviation program's SMS policy implementation are related to their safety compliance.

H_{10}: Respondents' perceptions of their collegiate aviation program's SMS policy implementation are related to their safety participation.

H_{11}: Respondents' perceptions of their collegiate aviation program's SMS policy implementation are related to their safety reporting.

H_{12}: Respondents' safety motivation mediates the relationship between their perceptions of their collegiate SMS policy implementation and safety compliance.

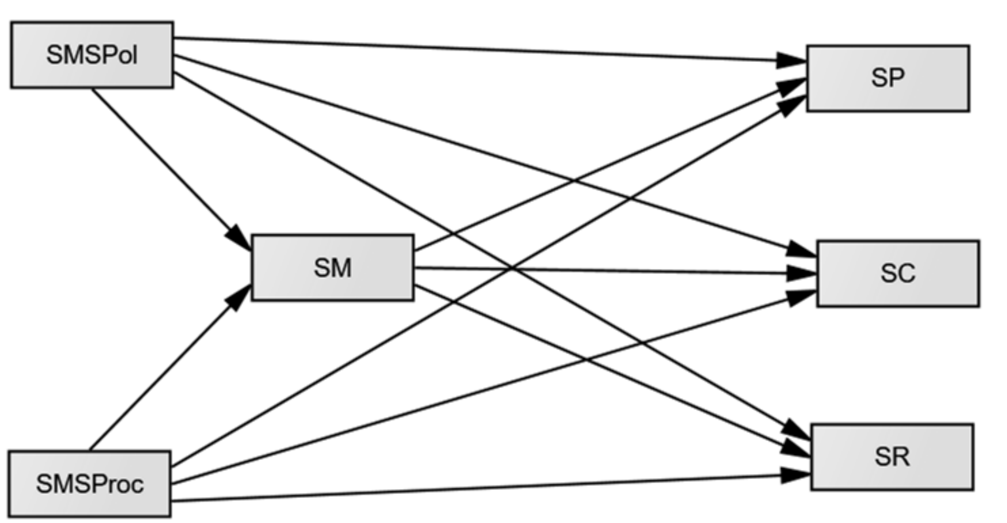
H_{13}: Respondents' safety motivation mediates the relationship between their perceptions of their collegiate SMS policy implementation and safety participation.

H_{14}: Respondents' safety motivation mediates the relationship between their perceptions of their collegiate SMS policy implementation and safety reporting.

The hypothesized measurement model to show the strength of relationships between all the study constructs is shown in Figure 1.

Figure 1

A Hypothesized Measurement Model Showing the Relationship Between SMS Process Engagement, SMS Policy Implementation, Safety Motivation, and the Outcome Variables: Safety Compliance, Safety Participation, and Safety Reporting



Literature Review

SMS in Collegiate Aviation

While SMS has been mandated at Part 121 airlines in the US (FAA, 2015b) and recommended for corporate Part 135 operations (NTSB, n.d.), there is no current mandatory requirement to have an SMS for general aviation (GA) organizations such as collegiate flight training programs. Therefore, if a GA organization wishes to pursue and implement an SMS in the U.S., it is voluntary and can choose from either the FAA SMS voluntary program (SMSVP) or the International Standards – Business Aviation Operations (IS-BAO) SMS of the International Business Aviation Council (IBAC) (International Busisiness Avaition Council, n.d.).

FAA SMS Voluntary Program (SMSVP)

A GA organization pursuing the SMSVP does not require formal membership in an aviation industry-best practices organization with a governing body and follows guidance published within the Flight Standards Information Management System Volume 17 (FAA, 2019). The GA organization will use this guide to structure its SMS and determine the elements needed to meet the FAA's acceptance requirements.

There are several steps in getting an SMSVP accepted by the FAA. The phases include Preparation Phase, Certificate Management Team (CMT) Implementation Plan Review Phase, Documentation Validation Phase, Design Demonstration Phase, Administrative Process Phase, and Continued Operational Safety (COS) (FAA, 2019). Furthermore, the certificate holder will pass through multiple categories denoting their progress: Active Applicant, Active Participant, and Active Conformance (FAA, 2019).

International Business Aviation Council (IBAC) SMS

Another option to implement SMS within GA organizations, such as collegiate aviation, is to pursue the IS-BAO standard through IBAC based on ICAO Standards and Recommended Practices (SARPs) Annex 19 (International Busisiness Avaition Council, n.d.). The cost factor is one immediate difference between pursuing the SMS through the FAA's SMSVP program and IS-BAO. It may be expensive for some organizations with limited financial resources to pursue the IS-BAO SMS.

IS-BAO requires membership and fees to be certified through IS-BAO. However, pursuing IS-BAO has some advantages, including generic manuals organizations can alter to meet the specific needs of their organization and advisors to assist with developing SMS principles in pursuit of the IS-BAO standard. However, IS-BAO is a third-party certification and not a recognized State Safety Oversight (SSO) body and cannot be a regulatory acceptance of SMS under ICAO Annex 19, which gives that prerogative to the FAA in the US (ICAO, 2018).

SMS and Safety Culture in Collegiate Aviation

There have been considerable amounts of research focused on the topic of safety culture in the context of multiple industries and disciplines including, but not limited to, energy (García-Herrero et al., 2013), healthcare (Groves et al., 2011), and aviation (Adjekum, 2014; Adjekum et al., 2015, 2016; Dillman et al., 2010; Gao & Rajendran, 2017; Gill & Shergill, 2004; Wang, 2018; Wu et al., 2010) and in an evolving environment of new technology, training, and productive processes, it is always expedient to continuously assess and improve the culture of safety in organizations (FAA, 2015a; ICAO, 2018).

There has been extant research (Adjekum, 2014, 2017; Gill & Shergill, 2004; McDonald et al., 2000; Remawi et al., 2011; Chen & Chen, 2012; Patanker & Sabin, 2010; Robertson, 2016; Stolzer et al., 2018) that assesses the nexus between Safety Management Systems and safety culture which is essential to an organization’s safety performance and a product of the values and actions of organizational leadership and learning (FAA, 2015a).

Robertson (2016) investigated different approaches to developing and implementing an SMS and the relationship between elements/processes of an SMS and strong safety culture among collegiate aviation programs. This research was entirely qualitative in its design, and it was suggested to develop quantitative studies to investigate the findings parallel to the qualitative components.

Adjekum (2014, 2017) and Robertson (2018) utilized quantitative designs to research safety culture in collegiate aviation with an SMS. The quantitative analysis used the Collegiate Aviation Program Safety Culture Assessment Survey (CAPSCAS). Adjekum (2014, 2017) developed and validated this tool using a sample from only one sizeable collegiate aviation program.

Robertson (2018) examined the relationship between SMS implementation, management commitment, and promotion and the safety culture of multiple flight training organizations using the CAPSCAS but adopted a descriptive statistical analysis and a non-parametric approach. There were no measurement models to explore hypothesized relationships among constructs and validity analysis.

Zubowsski (2021), in a study on measuring safety culture for SMS optimization, recommended a need for academia to improve the validity of assessment tools for safety culture and SMS in aviation. All these studies recommended further research across multiple universities and flight training organizations to further improve the validity of tools and measurement scales from previous research findings to bolster empirical evidence behind SMS implementation and safety culture perceptions in collegiate aviation.

The Federal Aviation Administration (FAA) of the US and the International Civil Aviation Organization (ICAO) both consider proactive safety culture as a veritable and desired outcome of effective SMS implementation and recommends that the relationship between these two concepts be assessed periodically as part of continuous safety improvement strategies (FAA, 2015a; ICAO, 2018).

There seems to be a paucity in the literature that addresses how addressing different types of SMS initiatives [i.e., FAA Safety Management System Voluntary Program (SMSVP) versus International Business Aviation Council (IBAC) International Standard for Business Aircraft Operators (IS-BAO)] affects safety culture perceptions in collegiate aviation programs.

Investigating whether differences in the type of SMS program pursued by a given institution will significantly influence safety culture perceptions among students and CFIs warrants empirical inquiry. Findings from such a study may help collegiate aviation institutions in their SMS voluntary program implementation planning and execution.

Adjekum et al. (2015, 2016) found significant effects of the year group and nationality on safety culture perceptions among collegiate aviation program demographics. This research was performed across multiple universities, and the authors recommended further studies with broader samples and different scopes and complexities of collegiate aviation programs to enhance the generalizability of research findings. The study also recommended probing the effects of international and domestic student status on safety culture perceptions in an SMS environment.

Some collegiate aviation programs are currently pursuing SMS for various reasons, including, but not limited to, proactive measures to improve safety and safety culture or to meet increasing accreditation standards from accrediting bodies. However, further research into the relationship between SMS implementation and safety culture is needed—especially in collegiate aviation, where the research is limited (Adjekum, 2017; Mendonca & Carney, 2017).

In the Adjekum (2017) study on SMS and safety culture, SMS policy implementation was found to have a significant direct effect on safety motivation, a significant direct effect on safety compliance, and a more substantial total effect on safety compliance when mediated by safety motivation. Moreover, SMS process engagement had a significant direct effect on safety participation and an even more substantial effect when mediated by safety motivation.

In addition, safety motivation had a significant direct effect on both safety compliance and safety participation with relatively high effect sizes. Adjekum (2017) suggested the beneficial effects of positive reinforcement, awards, public recognition, and other promotional material to motivate students and other personnel in collegiate aviation programs.

The findings from the study also suggested that safety motivational strategies could have positive effects on safety compliance and safety participation. The findings guided collegiate aviation programs in developing SMS policies related to behavioral components such as safety motivation, safety compliance, and safety participation. Adjekum (2017) recommended further studies to explore the relationships among the variables using data from various SMS implementation types.

Some extant studies have examined factors influencing collegiate aviation safety reporting behavior (Adjekum et al., 2015, 2016; Robertson, 2016, 2018). A strong reporting culture is considered a sought-after cultural state in any aviation organization bent on sustaining a proactive safety paradigm (Dekker, 2012; FAA, 2015a; ICAO, 2009; Reason, 1997).

Safety reporting, as stated earlier, was included in this study based on The Theory of Planned Behavior (TPB) (Ajzen, 1991) and suggests that in collegiate aviation programs, the perceptions of management support in providing resources that facilitate easy access to safety reporting can sustain an environment that can significantly influence the ability of respondents to participate in safety reporting programs (behavioral control).

The overt engagements by stakeholders motivated to utilize the safety reporting infrastructure within an organization suggest an intent to contribute to meeting critical organizational objectives of proactive safety risk management, which is also a tenet of the theory.

The engagement of all stakeholders in the safety reporting process suggests a cost-benefit mutual relationship where students and employees report safety hazards and senior management provides feedback and responses on mitigations to minimize risk to acceptable levels. The Social Exchange Theory undergirds this, and specifically, such organizational behavior be considered a form of safety citizenship behavior (SCB) (Hofmann et al., 2003; Wishart et al., 2019).

However, these studies did not explore the potential effects of different types of SMS implementations on safety reporting behaviors using multiple collegiate aviation programs. That provides a gap in research that needs to be filled. Finally, periodic assessment of the effects of SMS factors and safety motivation on safety reporting in these collegiate aviation programs can benefit the drive for continuous safety improvements.

Materials and Method

Research Design

The current study utilized a quantitative approach with a post-positivist worldview. Research participants were sought from various collegiate aviation programs that operate under 14 Code of Federal Regulations (CFR) Part 141 and are University Aviation Association (UAA) members. The student populations at these institutions vary from less than 100 students to as high as 1,500.

Moreover, these institutions all have varying levels and types of SMS programs. Some collegiate aviation programs did not have SMS but generic safety reporting systems. Some collegiate aviation programs were in various implementing phases of the FAA SMSVP, and another had used the IS-BAO SMS initiative. One of the programs had a well-established, FAA-recognized SMS program. Seeking collegiate aviation programs with these varying SMS implementation levels and types was necessary, given the research goals of determining any potential effects based on these factors.

Sampling Procedures

Power Analysis and Sample Size Selection

Kline (2011) suggests considering the model parameters when determining adequate sample size, as simpler models may work with a smaller sample. Conversely, more complex models require a larger sample. More specifically, Jackson (2003) offers the *N: q rule,* which is applicable when using the maximum likelihood estimation method and suggests a ratio of 20:1. That is, 20 participants to each parameter in the model. Given that the proposed model had 14 parameters, a minimum sample size of 280 participants was suggested. The final sampling pool of eleven collegiate aviation programs, some of which have over 1,000 students, provided ample participants for the study.

Given that the effect of the "year spent in the program" demographic variable on the outcome variable was of interest, it was prudent to include students and CFIs. Many students graduate and get hired by their respective institutions as CFIs to build time. This increased time at a given institution provides insight into the potential year-group effects. This sample provided responses from first-year students to graduated students working as CFIs who may have been at the institution for longer than four years.

Procedures for Recruitment, Participation, and Data Collection

The University of North Dakota (UND) Institutional Review Board (IRB) reviewed and approved the proposed research protocols. A purposive sampling approach was utilized. Departmental heads and chairs of the various collegiate aviation programs who participated in the study were contacted to request access to students, CFIs, and safety leadership personnel in their organizations. These leaders provided permission and access to the respondents.

A hyperlink was generated to grant access to an anonymous survey using a UND-hosted Qualtrics® link. This link was sent to the leaders previously contacted at each institution, who disseminated it to their respective students and CFI bodies through institutional email for secure access. Upon opening the link, participants were required to review the informed consent page and provide implied consent by opting to complete the survey. The responses to completed surveys were stored online through the Qualtrics® server as approved by the IRB.

Scale Items

The hypothesized measurement model used a five-point Likert scale (1 = strongly disagree to 5 = strongly agree or 1 = never to 5 = always) to measure scale items. In addition, scale items' reliability was checked using composite reliability, measurement model fitness was done using confirmatory factor analysis (CFA), and construct/discriminant validity was assessed for the factors. For scale item reliability, a minimum threshold value ($\alpha = 0.70$) was utilized in all cases, which is considered acceptable (Field, 2018). The questionnaire can be found in Appendix A.

Results and Discussion

Demographic Information

After four weeks, the survey was closed. Four hundred and fifty-one (n = 451) responses were considered for analysis based on respondents who completed the survey past the consent page. Sixty (n = 60) responses were deleted due to not consenting to the survey and did not provide adequate data for analysis. Any missing data were replaced using a regression-based single input method. A limitation of single-imputation methods is that they tend to underestimate error variance, especially if the proportion of missing observations is relatively high (Vriens & Melton, 2002, as cited in Kline, 2011).

Regarding the demographic variable "functional group," respondents who selected the "Other" category mainly included CFIs, students who had completed their coursework but were still flying, and graduate students. Those in the "Other" category do not fit into a traditional year group category as they do not retain traditional student status but continue to play a significant role in collegiate aviation operations. For this study, domestic students were categorized as US citizens or those having resident alien status (Green card holders).

Respondents were also asked to provide information about their organization's SMS status. This demographic question was meant to determine what type of SMS program their institution was pursuing or had accepted and whether the respondents knew this status. Tables 1, 2, 3, 4, and 5 provide details of the demographic distributions.

Table 1

Demographic variable of Year Group

Variable	N	Percentages
Year Group		
First-year student	94	20.8%
Sophomore	77	17.1%
Junior	82	18.2%
Senior	134	29.7%
Other	64	14.2%
Total	**451**	**100 %**

Table 2

Demographic Variables of Highest Flight Certificate Held and Gender

Variable	N	Percentages
Highest Flight Certificate Held		
Student	127	28.2%
Private	198	43.9%
Commercial	45	10.0%
CFI or ATP	80	17.7%
Missing	1	0.2%
Total	**451**	**100.0%**
Gender		
Male	360	79.8%
Female	88	19.5%
Missing	3	0.7%
Total	**451**	**100.0%**

Table 3

Demographic Variables of International Status and SMS Status

Variable	N	Percentages (%)
Are you an international student?		
Yes	36	8.0%
No	414	91.8%
Missing	1	0.2%
Total	**451**	**100.0%**
What kind of Safety Management System (SMS) does your institution have or currently pursuing?		
FAA SMSVP	246	54.5%
IS-BAO / Third-Party SMS	9	2.0%
Do not know	188	41.7%
None	7	1.6%
Missing	1	0.2%
Total	**451**	**100.0%**

DOI: 10.58940/2374-6793.1788

Table 4

Demographic Variable of University Affiliation – Flight Training and Employment

What University do you attend for flight training or currently employs you?		
Unknown	10	2.2%
University A	7	1.6%
University B	4	0.9%
University C	20	4.4%
University D	4	0.9%
University E	50	11.1%
University F	13	2.9%
University G	142	31.5%
University H	1	0.2%
University I	16	3.5%
University J	184	40.8%
Total	**451**	**100.0%**

Table 5

Demographic Variable of Functional Group

Variable	**N**	**Percentages (%)**
What is your functional group?		
Student	377	83.6%
Permanent Employee/Staff	61	13.5%
Faculty	12	2.7%
Missing	1	0.2%
Total	**451**	**100.0%**

Quantitative Data Analysis and Validation

The quantitative data in the form of an SPV file was downloaded from Qualtrics® into IBM SPSS Statistics 27® and IBM SPSS Amos 26 Graphics® for analysis. Unless otherwise specified, all analyses were assessed for statistical significance at the 0.05 alpha level (2-tailed). Descriptive analysis included mean, median, standard deviation, standard error of the mean, normality tests (kurtosis and skewness), and visual inspection of normal distribution curves. High indications of kurtosis were observed for two variables: Safety Motivation and Safety Compliance.

Given that regression-based single-imputation was used to replace missing values, there is the possibility that a high frequency of common values reduced the variance (Vriens & Melton, 2002, as cited in Kline, 2011). Visual inspection of the histogram for these variables showed positive peaks near the normal distribution curve's mean representative of these shared values. This is a limitation of any single-imputation method for replacing missing data (Vriens & Melton, 2002, as cited in Kline, 2011).

Given the use of previously validated scales in the present study, A first-order uni-dimensional confirmatory factor analysis (CFA) was performed on each construct explored in this study: SMSPol, SMSProc, SR, SC, SP, and SM. The CFA was used to determine whether scale items were consistent with the researcher's understanding of the nature of that construct among these respondents. It also tested whether the research data fit hypothesized measurement models of the relationships between study constructs/variables. CFA was also used for this analysis to determine the goodness of fit indices and factor loadings.

Additionally, convergent validity was assessed using the average variance extracted method (AVE). Fornell and Larcker (1981) suggest a value above 0.50 when assessing convergent validity. Finally, discriminant validity was assessed by comparing each AVE's square root with the correlation coefficients for each construct.

As part of the model assessment, there were various iterations to find the best-fit model among competing measurement models. Suggestions from the modification indices of IBM SPSS Amos 26 Graphics® and theoretical considerations were used in the iterative process. This first assessment resulted in post hoc modification to the initial measurement model of the SMSProc construct. Some low-factor loadings affected the fitness of the model. The modification resulted in removing two items (Q4.5, Q4.6), which had low loading from the original six. There were no other modifications made to scale items.

Composite reliability was calculated using an Excel spreadsheet for all items in the measurement model to assess the reliability of the items on each scale. All items assessed were above the 0.70 threshold except for SR ($\alpha = .60$). The relatively fair reliability of SR could be due to inadequate understanding and responses to the construct items by respondents or the low number of items that explained the construct (3). Table 6 has composite reliability values for all scales and descriptive statistics.

Table 6

Details of Descriptive Statistics and Composite Reliability of all the Study Variables

	SM	SP	SC	SR	SMSProc	SMSPol
N	451	451	451	451	451	451
Mean	3.99	3.61	4.46	4.63	2.78	3.83
Median	4.07	3.61	4.55	4.63	2.78	3.96
Std. Deviation	0.249	0.538	0.379	0.755	0.523	0.685
Skewness	-5.902	-0.958	-4.225	-1.041	-1.072	-2.379
Std.Error Skewness	0.115	0.115	0.115	0.115	0.115	0.115
Kurtosis	59.489	2.079	28.625	1.024	1.356	6.087
Std.Error Kurtosis	0.229	0.229	0.229	0.229	0.229	0.229
Composite Reliability	0.80	0.79	0.83	0.60	0.79	0.93
Number of Items in Scale	3	3	3	3	4	6

Convergent validity was assessed using the AVE method (Fornell & Larcker, 1981). The AVE method assesses the variance captured by the construct concerning the variance explained by error (Fornell & Larcker, 1981). The values for all scales were above the 0.5 threshold apart from SR (0.36). This suggests low evidence of convergent validity in the SR scale with other scales.

Discriminant validity was assessed by comparing the square root of each AVE with the correlation coefficients for each construct. If the square root of each AVE is more than the correlation coefficient, discriminant validity is believed to exist (Fornell & Larcker, 1981). Based on the analysis, discriminant validity can be assumed. See Table 7 for the values of AVE and correlations.

Table 7

The Square Root of the AVE (diagonal) and Correlations Between Constructs (off-diagonal)

	AVE	SP	SMSPol	SMSProc	SR	SC	SM
SP	0.56	**0.746**					
SMSPol	0.68	0.205	**0.823**				
SMSProc	0.50	0.094	0.219	**0.698**			
SR	0.36	0.358	0.318	0.412	**0.599**		
SC	0.63	0.453	0.310	0.276	0.295	**0.791**	
SM	0.57	0.332	0.394	0.286	0.318	0.493	**0.758**

Question One: ***What are the strengths of the hypothesized relationship between SMS process engagement, SMS policy implementation, and safety behavior measured by safety compliance and safety participation, and safety reporting behavior across multiple collegiate aviation programs when mediated by safety motivation?***

A Structural Equation Model (SEM) approach was used to determine the strength of relationships among the variables using Path Analysis (PA) and determine the fit of competing measurement models that explain these relationships. Model fit indices, namely Chi-square (χ^2), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Normed Fit Index (NFI), and Incremental Fit Index (IFI), were reported as part of the model fit assessment of the hypothesized measurement model showing the relationships between the variables.

The initial analysis of the fully mediated measurement model did not yield adequate goodness-of-fit indices. Based on recommendations suggested by IBM SPSS Amos 26 Graphics® modification indices function, covariances were added between the error terms to improve model fit. Covariances were added between e2/e3 and e2/e4, e3/e4, and e5/e6. Additionally, the direct path from SMSProc to SP was removed since there was no significant predictive relationship between them, and the regression weight was meager.

A second iteration resulted in an overfit model, which is not conducive to hypothesis testing (Brown, 2006; Kline, 2011). Based on the modification indices, the covariance between e3/e4 was removed, and the analysis was re-run. Finally, a third model was obtained with an acceptable fit which was adopted among the other competing models and used for hypotheses testing: $\chi2$ (2, n = 451) = 6.188, CMIN/DF = 3.094, p = .045, NFI = 0.992, IFI = 0.994, TLI = 0.958, CFI = 0.994, RMSEA = .068 (.009 - .132).

Table 8 shows all reported goodness-of-fit statistics for the competing models. See Figure 2 for a graphical representation of the final structural model showing the relationships between the study variables.

DOI: 10.58940/2374-6793.1788

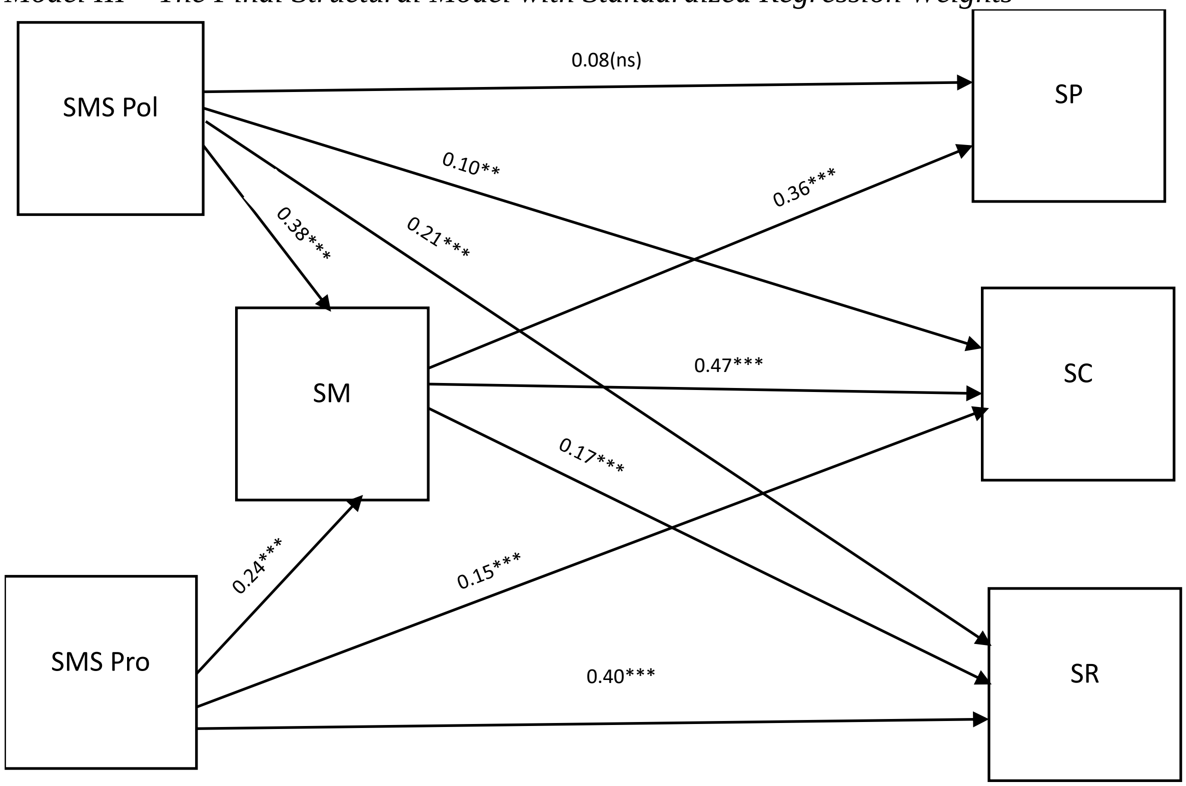
Table 8

Goodness-of-Fit Estimates for Various Structural Models

Iteration	Chi-square (χ2)	NFI	IFI	TLI	CFI	RMSEA
Model I	χ2 (4, n = 451) = 175.797 CMIN/DF = 43.949, p < .001	0.768	0.772	0.134	0.769	.309 (.271 - .349)
Model II	χ2 (1, n = 45.1) = .200 CMIN/DF = .200, p = .655 (Covary e2/e3, e2/e4, e3/e4, and e5/e6. Removal of SMSProc --> SP)	1.000	1.001	1.016	1.000	.000 (.000 - .096)
Model III	χ2 (2, n = 451) = 6.188, CMIN/DF = 3.094, p = .045 (Covary e2/e3, e2/e4, and e5/e6. Removal of SMSProc --> SP)	0.992	0.994	0.958	0.994	.068 (.009 - .132)

Figure 2

Model III – The Final Structural Model with Standardized Regression Weights



Note. ns – no significance, ** *p*< .01, ****p*< .001. Covariances were removed for clarity.

Hypothesis Testing Results

The 14 hypotheses initially postulated were assessed using the output of the SEM-PA. Standardized regression coefficients (β), standard error (SE), critical ratio (CR), and p-values are reported to show the effect the predictor variables have on outcome variables.

Hypothesis 1

The first hypothesis tested the relationship between SMSProc and SM. The results indicated that the relationship between SMSProc and SM was statistically significant (β = 0.243, SE = 0.020, CR = 5.737, p < .001) and supported the hypothesis. The direct effect of SMSProc on SM was .243. That is, due to the direct (unmediated) effect of SMSProc on SM, when SMSProc goes up by one standard deviation, SM goes up by 0.243 standard deviations.

Hypothesis 2

The hypothesis tested the relationships between SMSProc and SC. The results indicated that the relationship between SMSProc and SC was statistically significant (β = 0.145, SE = 0.028, CR = 3.83, $p < .001$) and supported the hypothesis. The direct effect of SMSProc on SC was 0.145.

Hypothesis 3

The hypothesis tested the relationship between SMSProc and SP. However, the adopted final measurement model had no relational pathway between the two variables; therefore, the hypothesis was not supported.

Hypothesis 4

The hypothesis tested the relationship SMSProc and SR. The results indicated that the relationship between SMSProc and SR was statistically significant (β = 0.401, SE = 0.055, CR = 10.484, $p < .001$) and supported the hypothesis. The direct effect of SMSProc on SR was 0.401.

Hypothesis 5

The hypothesis stated that SM mediates the relationship between SMSProc and SC. The results indicated that SM significantly mediated the path between SMSProc and SC. The indirect effect coefficient was 0.113 and was statistically significant ($p = .003$). The standardized total (direct and indirect) effect of SMSProc on SC is .258. Due to both the direct (unmediated) and indirect (mediated) effects of SMSProc on SC, when SMSProc goes up by one standard deviation, SC goes up by 0.258 standard deviations.

Hypothesis 6

The hypothesis stated that SM mediates the relationship between SMSProc and SP. While the direct path from SMSProc to SP was not included in the final measurement model, the mediated pathway showed statistical significance ($p = .006$). The indirect effect coefficient was small (.087), and the standardized total (direct and indirect) effect of SMSProc on SP was .087. The results do support the hypothesis.

Hypothesis 7

The hypothesis stated that SM mediates the relationship between SMSProc and SR. The results showed a statistically significant effect for SM mediating the relationship between SMSProc and SR ($p = .009$). The indirect path coefficient was .042, and the standardized total (direct and indirect) effect of SMSProc on SR is .443. These results supported the hypothesis.

Hypothesis 8

The hypothesis tested the relationships between SMSPol and SM. The results indicated a statistically significant relationship (β = 0.376, SE = 0.015, CR = 8.889, $p < .001$) and supported the hypothesis. Furthermore, the direct path coefficient between SMSPol and SM was .376. Therefore, due to the direct (unmediated) effect of SMSPol on SM, when SMSPol goes up by one standard deviation, SM goes up by 0.376 standard deviations.

Hypothesis 9

The hypothesis tested the relationships between SMSPol and SC. The results indicated a statistically significant relationship (β = 0.103, SE = 0.057, CR = 2.408, p = .016), supporting the hypothesis. The direct path coefficient between SMSPol and SC was .103.

Hypothesis 10

The hypothesis stated that SMSPol was related to SP. The result did not indicate a statistically significant relationship between SMSPol and SP (p = .098) and did not support the hypothesis.

Hypothesis 11

The hypothesis stated that SMSPol was related to SR. The results indicated a statistically significant relationship between SMSPol and SR (β = 0.206, SE = 0.047, CR = 4.857, p < .001) and supported the hypothesis. The direct path coefficient between SMSPol and SR was .206.

Hypothesis 12

The hypothesis stated that SM mediates the relationship between SMSPol and SC. The results indicated a statistically significant mediating role of SM between SMSPol and SC (p = .003). The indirect path coefficient between SMSPol and SC was .175, with a total path coefficient of .278.

Hypothesis 13

The hypothesis stated that safety motivation mediates the relationship between SMSPol and SP. The results showed a statistically significant mediating effect of SM between SMSPol and SP (p = .006). The indirect path coefficient between SMSPol and SP was .135, with a total effect of .214. Despite the direct path between SMSPol and SP not being statistically significant (p = .098), the mediated path through SM was statistically significant and supported the hypothesis.

Hypothesis 14

The hypothesis stated that safety motivation mediates the relationship between SMSPol and SR. The results indicated a statistically significant mediating effect of SM between SMSPol and SR (p = .007). The indirect path coefficient between SMSPol and SR was .065, with a total path coefficient of .271. These results supported the hypothesis.

Table 9 contains significance values for mediating effects and squared multiple correlations (R^2) for effect size, which provides the variance in the endogenous variables explained by the exogenous variables (Byrne, 2010). Appendix B provides a tabular summary of the hypothesis findings.

Table 9
Indirect Effects - Two-Tailed Significance and R^2 Effect Size

	SMSProc	SMSPol	R^2
SM	...	...	0.245
SP	0.006	0.006	0.160
SR	0.008	0.007	0.351
SC	0.003	0.003	0.344

Question Two: *What are the differences in perceptions of safety behavior and safety reporting per demographic variables (year group, international student status, SMS status, and flight certification) across multiple universities with collegiate aviation programs?*

A one-way between-subjects Analysis of Variance (ANOVA) was used to assess differences in the mean perception scores for respondents on outcome variables based on various demographical groups. The *Levene test* for homogeneity was used before all tests to verify normal variances among the data. A robust approach entailing bootstrapping was used if assumptions of normal variance could not be assumed.

The first demographic group assessed was the year group. The results indicated a significant difference in the means score for SR based on year-group, F (4, 446) = 2.706, p = .001, η^2 = .042. Since the sampling size between groups differed slightly, Gabriel's procedure was used for post-hoc analysis (Field, 2018).

The post-hoc analysis revealed significant differences in mean reported scores on SR. Seniors had a lower perception score (M = 4.41, SD = .82) than first-year students (M = 4.71, SD = .75), Sophomores (M = 4.81, SD = .67), and Others (M = 4.76, SD = .82). The results suggest that sophomores had the highest mean scores.

International student status was also assessed to determine any varying perceptions of the outcome variables. Levene's test of homogeneity was significant, F (1, 448) = 6.40, p = .012. Therefore, an independent samples t-test with bootstrapping was performed to address assumptions of normality (Field, 2018).

International students had lower mean scores (M = 4.32, SD = .92) as compared to non-international students (M = 4.66, SD = .73). This difference, -.34, BCa 95% CI [-.67, -.03], was significant, t (38.96) = -2.17, p = .036, which represented an effect of d = .75. This result suggests that domestic students had a better perception of SR than international students.

Respondents were asked to provide information regarding their university's SMS implementation status. This question was meant to determine if the school was actively pursuing a formal SMS (i.e., FAA SMSVP or IBAC IS-BAO), had already implemented an SMS, was not pursuing a formal SMS, or did not know what their university's intentions were regarding SMS implementation. Notably, many respondents answered that they did not know their university's SMS implementation plans (n = 188).

A one-way ANOVA was run to determine if there were any differences in the mean of responses to SC, SP, or SR based on this SMS status question. The results suggested significant differences in the mean scores on SP based on SMS status, F (3, 446) = 2.71, p = .045, η^2 = .018.

In addition, post-hoc analysis using Hochberg's GT2 procedure was conducted. It showed that respondents that answered *Do Not Know* (M = 3.52, SD = .53) had significantly lower mean scores than respondents that indicated their institution was pursuing a formal SMS through the FAA's SMSVP (M = 3.67, SD = .54).

A one-way ANOVA was run to determine if there were any significant differences in responses to the outcome variables based on respondents' flight certificates. No significant differences were found based on this demographic variable were found.

Discussion

This study sought to build upon past research into SMS and safety culture in collegiate aviation programs (Adjekum, 2014, 2017; Adjekum et al., 2015; Freiwald et al., 2013; Gao & Rajendran, 2017; Hasan & Younos, 2020; Robertson, 2016; Robertson, 2018). SMS implementation in collegiate aviation is still fledgling, and few collegiate aviation programs have implemented formal SMS programs recognized by a regulatory body such as the FAA or an industry trade organization such as IBAC.

However, since entities such as AABI and UAA encourage SMS, it is envisaged that more collegiate aviation programs will be pursuing formal SMS implementation, and this research sought to assess the effect of SMS factors on tangible safety performance metrics such as safety behavior and safety reporting while comparing potential differences in colleges with and without formal SMS programs.

SMS Implementation and Safety Behavior

SMSPol was found to have a significant effect on three variables: SM, SR, and SC. However, there was an insignificant effect of SMSPol on SP, similar to previous findings from Adjekum (2017). Interestingly, even though the direct path from SMSPol and SP was not significant in both studies, the mediation of SM provided a significant path from SMSPol to SP.

This finding suggests that an SMS policy singularly does not guarantee safety participation behavior among these collegiate respondents. Instead, safety motivation is needed to enhance safety participation, which has theoretical underpinnings with the Theory of Planned Behavior motivation element.

The significant effect of SMSPol on SR and SC was instructive and provides value for safety improvements. The SR scale was designed to assess the willingness and frequency by which respondents utilized the safety reporting system. Similarly, the SC scale assessed the extent to which participants followed policies and procedures stipulated by their organization.

The findings suggest that active participation in safety reporting behavior and safety compliance behavior is a desired safety performance outcome for organizations as part of SMS implementation and buttresses the safety citizenship tenets of the Social Exchange Theory (SET). The results suggest that as part of any SMS implementation, responsive and well-articulated policy guidelines on safety reporting and safety compliance standards can have a significant effect on observable behavioral metrics such as SR and SC.

The predictive relationship between SMSPol and SM was one of the more significant relationships in this study ($\beta = .376$). When organizational leadership articulates the importance of safety as a core value through policy guidelines to stimulate desired safety behavior, it can encourage a higher level of commitment to the organization's goals (Ford & Tetrick, 2008).

Given that the SMS policy is meant to convey an organization's stance on the role of safety within their organization and provide safety objectives, this could explain the significant impact of SMSPol on SM. These results suggest that a well-defined SMS policy can motivate stakeholders while encouraging the desired safety behavior.

Adjekum (2017) found a significant effect of SMSProc on SP. However, due to low factor loading and to facilitate model improvements, the direct path between SMSProc and SP was removed. Moreover, Adjekum (2017) did not find a significant effect in the relationship between SMSProc and SC, while in this study, a significant effect was observed. This finding was interesting as the population in both studies were collegiate aviation respondents. This finding suggests that as respondents are drawn from multi-collegiate populations, institutional differences in SMSProc and SC requirements can influence study outcomes and should be anticipated.

It is also worth noting that SMSProc assesses how the stakeholders perceive their engagement with SMS-related processes in the organization, while SC assesses how respondents comply with the organization's safety expectations. This finding suggests that when stakeholders are provided with clearly defined and realistic safety expectations, compliance with these expectations can be better, which invariably influences positive engagements with SMS processes in collegiate aviation programs.

The predictive relationship between SMSProc and SR was one of the more significant relationships in this study ($\beta = .401$). Since some of the items in the SMSProc scale include elements defining what is supposed to be reported and the nature of the non-punitive reporting system, it is intuitive that these elements should positively influence SR. Nonetheless, this finding supports the notion that having clearly defined expectations of what is supposed to be reported through the organization's safety reporting system and implementing a non-punitive reporting system encourages reporting behavior.

SMSProc also had a positive effect on SM. This finding is another difference from past research studying the relationship between SMSProc on SM. Adjekum (2017) did not observe a significant effect in the relationship between SMSProc and SM and suggested that collegiate aviation programs should actively engage students and CFIs in SMS processes such as risk assessment and safety assurance projects.

It is plausible that since the Adjekum (2017) study, some collegiate aviation programs implementing SMS and those who have fully-fledged SMS adopted those recommendations, accounting for the different results observed in the present study. The larger sampling pool to include multiple universities with varying SMS implementation levels, status, and safety culture could also explain this different finding.

Adjekum (2016) found out from interviews with collegiate aviation leadership that engaging students, student organizations, and flight instructors during SMS implementation could address some concerns regarding apathy toward the SMS initiative.

Keeping these stakeholders involved could better inform them of their role in the SMS and address relationship barriers between frontline personnel and top management (Adjekum, 2016). The role of safety leadership in engendering active engagement in safety activities can positively impact safety behaviors (Clarke, 2013; Cooper, 2015; Shen et al., 2017).

Safety Motivation

The relationship between safety motivation and safety behavior has been explored in previous studies (Adjekum, 2017; Chen & Chen, 2014; Christian et al., 2009; Ford & Tetrick, 2008; Ji et al., 2017; Neal & Griffin, 2006; Vinodkumar & Bhasi, 2010) and the findings in this study corroborate some of the earlier works while adding to the growing research base on collegiate aviation safety behavior.

A significant predictive relationship existed between SM and SP ($\beta = .359$) and SC ($\beta = .466$). There was also a significant predictive relationship between SM and SR, albeit a small regression weight ($\beta = .172$) compared with SP or SC. This finding reinforces the notion that safety motivation can strongly predict safety behavior.

Another key takeaway from the findings regarding SM was its mediating role for SMSPol and SMSProc as they related to the outcome variables. SM significantly mediated the path from SMSPol and SMSProc to the outcome variables in all cases. An implication for policy and practice is that collegiate aviation leadership should recognize and acknowledge desired safety behaviors and be personally invested in SMS processes to motivate other stakeholders, such as students and CFIs, to be partners in safety improvements.

This finding is especially interesting when considering the effects of SMSPol on SP or SMSProc on SP. SMSPol did not have a statistically significant direct effect on SP, and the direct path from SMSProc to SP was removed due to low factor loading for model improvements. However, the effect became significant when SM was included in the path as a mediator. These findings suggest that SMSPol and SMSProc may not be adequate in influencing SP and requires safety motivation as an additional leverage. Again, these results emphasize the critical role of SM in predicting safety behaviors.

Safety motivation also played a significant role in amplifying the effects of SMSPol and SMSProc on SC and SR. While both SMSPol and SMSProc were shown to affect SC and SR significantly, these effects were amplified when SM was included as a mediator.

The larger indirect effects observed were on SC. These results show a direct effect of SMSPol and SMSProc on SC, but SM amplifies these effects. This suggests that even though SMSPol and SMS Proc can positively influence SC, an enhanced effect is observed with the element of safety motivation.

Implication for Theory

The validated measurement model that outlines the relationships between SMS and the behavioral constructs provides a baseline for understanding the conceptual underpinnings of SMS as a veritable tool to influence safety culture in collegiate aviation. The model also provides a framework for assessing the strengths of these relationships to enable policymakers to understand and appropriately earmark resources to areas relevant to continuous improvements in collegiate aviation safety, as Zabowski (2021) recommended.

Implication for Policy

The findings from this study suggest that a policy to initiate SMS in collegiate aviation operations provides a positive value proposition geared at desired safety behaviors (safety participation, safety compliance, and safety reporting) which are essential for sustaining a generative safety culture.

Demographic Effects

Past research has found effects on safety-related outcome variables based on demographic variables such as year group (Adjekum et al., 2015; Gao & Rajendran, 2017) and international student status (Adjekum, 2014; Adjekum et al., 2015; Noort et al., 2016). Therefore, the present research aimed to investigate these effects across multiple universities where some have fully implemented SMS programs. Moreover, given the implementation of SMS at some collegiate programs, it was desired to seek whether there are differences in safety-related behaviors based on SMS implementation status.

Year-Group Effects

Respondents were asked to provide their year group instead of age. Since age can sometimes be a misleading indicator of student status (i.e., non-traditional students who are older but just beginning their college experience), the year group was determined to be a better indicator of experience in the collegiate aviation program.

The present study found statistically significant differences in safety-reporting behavior based on year group. Specifically, Senior students were found to have significantly lower reported safety reporting behavior. This corroborates previous findings investigating this same topic (Adjekum et al., 2015, 2016).

Interestingly, students with more experience at their institution tend to have better perceptions regarding safety culture (Adjekum, 2014). However, the present study observed a decrease in reporting by senior students, similar to prior studies investigating reporting behavior in collegiate aviation (Adjekum et al., 2015, 2016). These findings show that decreased reporting behavior from senior students warrants administrators' attention and those in safety leadership positions.

Safety reporting is considered an essential element for SMS (FAA, 2015a; ICAO, 2009); therefore, this decreased reporting frequency is concerning, and the suggestions for top management and leaders not to disregard senior students to focus more on younger students and ensure adequate feedback may be an effective measure (Adjekum et al., 2015, 2016)

Respondents categorized under the *Other* category had increased reporting. The respondents who selected *Other* were CFIs, graduate students, or flight students who have completed their coursework but still need to fly. Even though some upper-classmen were included in this group, they still exhibited increased safety reporting as measured by the SR scale.

Some respondents in this group would be considered *more* senior than senior-level students. While this group had higher reported mean scores for reporting behavior than senior-level students, there were no statistical differences compared to first-year, sophomore, or junior students.

International Students

Variations in reporting behavior between domestic and international students were statistically significant. Specifically, domestic students were found to have higher scores for reporting behavior compared to international students. This, again, has been found multiple times in prior research (Adjekum et al., 2015; Liao, 2015; Noort et al., 2016). These findings highlight the role of cultural influences on student behavior, as suggested by Hong et al. (2022).

Given that these two groups exhibit variations in safety reporting behavior, there is a need to consider these cultural differences when structuring and managing the SMS. Language barriers may serve as a viable explanation for this decreased reporting behavior.

For international students who use English as a second language, reporting or filing a safety report requiring details in English may be challenging. That may play a role in their unwillingness to participate in the reporting system, and future qualitative-based research could explore in depth some of the reasoning behind this assumed possibility.

Liao (2015) provided three recommendations when dealing with cross-cultural behavioral barriers in safety reporting, which can be salient here: leadership, power distance, and incentive programs. Leadership was believed to play a substantial role in building subordinate trust to encourage reporting. Power distance can negatively influence reporting behavior based on cultural norms and perceptions.

Collegiate aviation leadership should note these barriers and structure reporting systems to minimize these factors by creating simplified reporting formats/taxonomies that require less narrative and, where narratives are required, must allow for multilingual submissions which can be interpreted. In addition, CFIs must ensure a conducive instructional environment that allows these international students to voice safety concerns and minimize power distance. Finally, cases of intimidation or harassment by CFIs that can stifle feedback must be investigated and judiciously adjudicated by top leadership.

Lastly, flight points or time incentives could facilitate better participation from these international students who are reluctant to share safety information. For example, a system of giving hypothetically free 10 minutes of flight time for voluntary reporting of safety concerns via the safety reporting system could improve participation.

The anticipated drawback may be sacrificing confidentiality since the reporter must be known to benefit from the incentive. However, a cost-benefit may inure to the enhanced reporting over time. While these recommendations may not address all cultural differences that influence reporting behavior variations, they can be a positive step, and further investigation into such cultural differences is warranted.

SMS Status

Respondents were asked to provide their SMS implementation status by answering the question *What kind of Safety Management System (SMS) does your institution have or is currently pursuing?* This question was initially designed to assess the potential effects of differing levels of SMS implementation on the outcome variables.

However, the findings showed that a sizable proportion of respondents did not know what kind of SMS their institution had in place or was pursuing. This was an intriguing finding as even institutions with fully implemented SMS programs responded as not knowing or indicating the wrong type of SMS.

As a result of this finding, an analysis was done to determine any potential effect of respondent understanding of their SMS status on the outcome variables using cross-tabs. The results indicated that respondents who did not know their institution's SMS status had statistically significantly lower mean scores on the SP scale than those who responded with the correct type. This shows a knowledge gap between respondents and their institutions' SMS status. It also reinforces the positive role an awareness of SMS initiatives can have on respondents' safety participation behaviors.

This knowledge gap is something that could be addressed by safety leadership. Evidence shows that individuals take more pride in their work when they have a sense of ownership (Adjekum, 2017; Patankar & Sabin, 2008). An improved understanding of what SMS is and how it works could improve safety participation. Implementing initial and recurrent higher-level SMS courses as part of collegiate aviation program academic syllabuses may be helpful.

As part of the courses, there should also be a focus on more applied concepts that allow students to engage in practical projects involving safety risk management and safety assurances in fleet operations or developing safety reporting systems. These hands-on projects could be used to assess the potential effects of enhanced SMS knowledge on safety behavioral factors such as participation.

Ensuring that initial and recurrent SMS training is provided to all stakeholders, not just students, would be another element to verify. Future research could address this in a quasi-experimental manner by implementing an SMS training initiative to determine if there are effects on safety participation perceptions.

Limitations

While the researchers targeted a purposive sample from the population of respondents from US collegiate aviation programs with SMS, there were still issues with unequal sample sizes from the survey part of the research. This could lead to higher and lower representations of individual institutions' perceptions regarding the studied variables.

Quantitative surveys are sometimes prone to biases and subjectivity. Self-serving bias, framing effects, and response biases can affect responses and need to be considered when making inferences from surveys. However, every effort was made to minimize these biases and subjectivity through a face validity test of items and reverse-coding some items to minimize framing effects. For some scales, the low-reliability scores, such as safety reporting, may suggest comprehensibility issues with items in the scale and may need future re-wording and re-validation.

All the analyses were done based on respondents' perceptions of which environmental factors and incidental safety occurrences in the program can influence. Therefore, adverse perceptions may be captured due to such one-time safety occurrences that may not reflect the actual long-term safety culture in the program.

Conclusions and Recommendations for Future Research

This study utilized a previously validated tool to measure the strength of relationships between two factors of SMS initiative, namely SMS Policy Implementation and SMS Process Engagement, and components of safety behaviors (safety participation, safety compliance, and safety reporting) across multiple collegiate aviation programs in the US. In addition, the mediation role of safety motivation was also assessed.

Various measurement models that assess the hypothesized relationships were evaluated, and the final model selected had an acceptable fit over all the goodness-of-fit indices reported. A path analysis using the best-fitting model suggested that these SMS factors have significant predictive relationships with safety behaviors, with effect sizes ranging from small to medium effects. Furthermore, safety motivation was a significant mediator in the relationships between the factors of SMS initiatives and all the components of safety behaviors.

Regarding the effects of demography on these variables, there were significant statistical differences in the mean scores on study constructs for both year-group and international student status demographics. Specifically, senior or upper-level students were found to have significantly lower reported safety reporting behavior than lower-level students.

Additionally, domestic students were found to have higher scores for safety reporting behavior compared to international students. Ensuring desired safety behavior for all student groups is crucial for optimal safety performance as these collegiate aviation programs strive for continuous safety improvements.

Ensuring equitable safety promotion efforts, such as initial and recurrent SMS training targeting all stakeholders within collegiate aviation programs, could be a good start. Similarly, active engagements of international students in developing or restructuring safety reporting programs that allow for multilingual submissions may be helpful to stimulate safety reporting among this group.

There is still a need to perform longitudinal studies to investigate the effects of SMS implementation on safety culture in collegiate aviation programs in the US. Analyzing a cohort of students throughout their tenure at an institution would provide a new perspective on how some variables are affected over time. This could require identifying these cohorts early on in their tenure and evaluating them yearly to determine these effects.

An evaluation of the potential effects of enhanced SMS training for students and CFIs is needed. Given the knowledge gap in the current research, there is potential to address this finding. A quasi-experimental approach before and after an SMS training initiative may determine any potential effects of enhanced SMS knowledge on safety behavior.

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Appendix A

Demographic Details

Q2.1 Year Group: Freshman (1) Sophomore (2) Junior (3) Senior (4) Other (5)
Q2.2 Highest Flight Certificate Held: Student (1) Private (2) Commercial (3) Certified Flight Instructor or Air Transport Pilot (4)
Q2.3 Gender: Male (1) Female (2)
Q2.4 Are you an international student? Yes (1) No (2)
Q2.5 What University do you attend for flight training or currently employs you?
Q2.6 What kind of Safety Management System (SMS) does your institution have or is currently pursuing? FAA accepted SMS Voluntary Program (SMSVP) (1) International Standards-business Aircraft Operations (IS-BAO) / Third-Party Vendor SMS (2) Do not know (3) None (4)
Q2.7 What is your functional group? Student (1) Permanent Employee/Staff (2) Faculty (3)

Scale Items

Q3.1 Please provide your degree of agreement regarding the following statements about the Safety Management System (SMS) in your flight program. Strongly disagree (1) Disagree (2) Neither agree nor disagree (3) Agree (4) Strongly Agree (5)

> Q3.2 The safety policy is signed and approved by the University President, Dean, or other Accountable Executive, who demonstrates a commitment to safety through active and visible participation in the SMS.
> Q3.3 The results of safety performance reviews are used by the program leadership as input for safety improvement processes.
> Q3.4 There is a process that provides for the capture of information on hazards, incidents, accidents, and other data relevant to SMS.
> Q3.5 Safety professionals with appropriate skills, knowledge, and experience conduct SMS training.
> Q3.6 There is a high emphasis on providing adequate financial and technical resources to improve the SMS.
> Q3.7 Policies and procedures in SMS manual are easy to understand.

Q4.1 Please provide your degree of agreement regarding the following statements about the SMS in your flight program. Strongly disagree (1) Disagree (2) Neither agree nor disagree (3) Agree (4) Strongly Agree (5)

> Q4.2 Conditions under which punitive disciplinary action would be considered (e.g. illegal activity, negligence, or willful misconduct) are not clearly defined.
> Q4.3 Students/Personnel are not informed of the primary contacts for aviation safety-related matters.
> Q4.4 The scope of the safety-related hazards that must be reported is not explained to students/personnel.

Q4.5 Safety concerns reported through the safety reporting system are corrected in a timely manner.
Q4.6 Knowing how and where to report safety concerns is easy.
Q4.7 Safety reporting system does not provide confidentiality for safety reports filed and feedback received.

Q5.1 Please provide your degree of agreement. Never (1), Sometimes (2), About half the times (3), Most of the time (4), Always (5)

Q5.2 I file reports about unsafe situations, even if the situation was caused by my own actions.
Q5.3 I file reports on safety deviations without fear of negative outcomes.
Q5.4 I do not report unsafe actions of others because I am not empowered to do so.

Q6.1 Please provide your degree of agreement regarding the following statements about yourself. Never (1), Sometimes (2), About half the times (3), Most of the time (4), Always (5)

Q6.2 I pay full attention to pre-flight briefing during flight operations.
Q6.3 I follow correct safety procedures in flight operations.
Q6.4 I ensure the highest level of safety in flight operations.

Q7.1 Please provide your degree of agreement regarding the following statements about yourself. Never (1), Sometimes (2), About half the times (3), Most of the time (4), Always (5)

Q7.2 I promote the safety program within the flight program.
Q7.3 I put in extra effort to improve the flight safety program.
Q7.4 I volunteer for safety-related task in the flight program.

Q8.1 Please provide your degree of agreement regarding the following statements about yourself. Strongly disagree (1) Disagree (2) Neither agree nor disagree (3) Agree (4) Strongly Agree (5)

Q8.2 It's worthwhile to improve personal safety.
Q8.3 It's important to maintain safety at all times.
Q8.4 It's important to reduce the risk of safety events in flight operations.

Appendix B

Table B1

Estimates of Final Measurement Model

Interactions			Estimate	SE.	CR.	P	β	Direct Effect	Indirect Effect	Total Effect	Hypothesis Testing
SP	<---	SMSPol	0.062	0.037	1.656	0.098	0.080	0.080	0.135	0.214	Not Supported
SM	<---	SMSPol	0.137	0.015	8.889	***	0.376	0.376	0.000	0.376	**Supported**
SC	<---	SMSPol	0.057	0.024	2.408	0.016	0.103	0.103	0.175	0.278	**Supported**
SR	<---	SMSPol	0.228	0.047	4.857	***	0.206	0.206	0.065	0.271	**Supported**
SP	<---	SM	0.765	0.102	7.471	***	0.359	0.359	0.000	0.359	**Supported**
SC	<---	SM	0.710	0.067	10.661	***	0.466	0.466	0.000	0.466	**Supported**
SR	<---	SM	0.523	0.132	3.954	***	0.172	0.172	0.000	0.172	**Supported**
SC	<---	SMSProc	0.105	0.028	3.830	***	0.145	0.145	0.113	0.258	**Supported**
SR	<---	SMSProc	0.580	0.055	10.484	***	0.401	0.401	0.042	0.443	**Supported**
SM	<---	SMSProc	0.116	0.020	5.737	***	0.243	0.243	0.000	0.243	**Supported**

Note ***p<.000, **p<.001, *p<.05