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Safety perceptions of training pilots based on training institution and experience

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ABSTRACT

This study examines training pilot survey data in order to determine how students' years of education and the institutions that they attend affect their perceptions of the risk factors in aviation as assessed using the SHELL model (software, hardware, environment, and liveware). The results reveal that student pilots lack confidence with respect to their knowledge during flights; moreover, they fail to recognize the importance of maintaining relationships among supporting staff such as air traffic controllers, mechanics, and others involved in the flight process. The findings suggest that to meet an increased demand for pilots, newly approved training centers are needed, centers which will foster awareness of interaction between human factors and other aspect of aviation safety; to support this, there should be more standardization of curricula.

1. Introduction

In Northeast Asia, substantial economic growth in China has resulted in increased demand for aviation operations—despite the limited availability of resources to provide them (Boeing, 2015a). Likewise, a growing need for air travel in the Asia-Pacific in general has resulted in increased demand for pilots in the region (Boeing, 2015b). In an attempt to meet this demand and reduce a reliance on foreign pilots, as well as addressing the drain of Korean pilots to Chinese or Middle East carriers (Wong, 2016), the Korean government sanctioned the establishment of approved training organizations (ATOs) in July 2010. Consequently, domestic flight training should steadily increase. Each flight training center must have their curricula, methods, equipment, and tools certified by the government while flight training has a better safety record than general aviation as a whole in the USA (Air Safety Institute, 2014). Flight training programs must promote error avoidance, assist in the early detection of errors, and minimize the consequences of errors when they occur (Salas et al., 2001); such training focuses on the effects of negligence and unsafe behaviors in a complex system (Reason, 1990), on mutual relationships (Cooper, 2000), and on the human-error framework (i.e., the human factors analysis and classification system) proposed by Wiegmann and Shappell (2003).

Researchers have examined pilot-specific factors such as gender (McFadden, 1996), personality (Carretta et al., 2014), situational/personal characteristics (Hunter et al., 2011), age (Hardy and Parasuraman, 1997; Li et al., 2003), experience (Wiggins and O'Hare, 1995; Adamson et al., 2010), education/training (Adamson et al., 2010), and style of learning (Fanjoy and Gao, 2011), in addition to airline-specific factors (McFadden, 2003). Other studies have focused on collegiate aviation pilot programs (Adamson et al., 2010; Adjekum, 2014; Fanjoy and Gao, 2011), wherein novice pilots are taught visual and instrumental flight rules, as well as how to operate aircraft and appropriately respond to various situations. The importance of training pilots regarding risk factors cannot be overemphasized because the success of a collegiate aviation program with a safety management system initiative is strongly influenced by the safety culture of its front-line personnel, including certified instructors and students (Adjekum, 2014).

This study focuses on the relationship between students' flights experiences and the institutions they attend and their perceptions

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of risk factors. An ideal safety assessment would examine each flight's associated risk factors; however, doing so would entail collecting hard-to-obtain data such as the age and experience of each respective pilot, measuring the instructor pilot's capabilities, procuring aircraft maintenance records, determining a given aircraft's age, and recording each flight's weather conditions. This research instead examines each student pilot's perceptions in light of the SHELL (Software, Hardware, Environment, Liveware and Liveware) interface model, which is designed to prevent human error.

1.1. The SHELL model

Elwyn Edward developed the SHELL model, a conceptualization and systematic visualization of relationships between crew and aircraft system components. Edward maintained that the human factors theory is more problem-solving oriented than problem-theory oriented-that is, it focuses on practical rather than academicals approach; he further asserted that it is essential for human performance and its limitations to be understood in tandem in order to resolve discrepancies between humans and their surrounding environments (Hawkins and Orlady, 1993; Keightley, 2004). Hawkins later transformed Edwards' model into a building block structure, wherein crew and aircraft system components function as a foundation. The human element, which is the most critical component, lies at the center and is influenced by software, hardware, the environment, and other individuals in the workplace (e.g., cockpit crew, air traffic controllers, management, and administrative and maintenance personnel). The SHELL model adopts a systems perspective and rarely deems humans to be the sole cause of accidents. The research model adopted by this study is based on the SHELL interface model, which comprises liveware (L), liveware–software (L–S), liveware–hardware (L–H), liveware–environment (L–E), and liveware–liveware (L–L) variables (see Appendix). The L variables pertain to human performance, capabilities, and limitations (ICAO, 1993). The L–S variables concern interactions between human operators and software, including (but not limited to) rules, procedures, and procedural information (Hawkins and Orlady, 1993; Wiener and Nagel, 1988). L–H variables involve human operators and machines (Hawkins and Orlady, 1993). L–E variables include interactions between human operators and internal/external environments as well as the adaption of a given environment to meet human requirements (Johnston et al., 2001; Wiener and Nagel, 1988). Finally, L–L variables include interactions between human operators performing tasks and other individuals in the aviation system (ICAO, 1993).

Fig. 1 and the Appendix describe the model and provide details regarding the aforementioned variables. The study's research hypotheses were assessed in terms of how flight experiences and organizations affect interactions between humans and risk factors (i.e., student pilots' perceptions concerning the effect of risk factors on safe aircraft operation). This paper is organized as follows. Section 2 sets out the research method and hypotheses. Section 3 investigates statistical results and the research hypotheses. Section 4 provides a discussion based on the results.

2. Method

The Korean air force, army, and navy, in addition to the Korea Aerospace University (KAU) and Hanseo University (HU), are among the organizations designated to operate pilot training programs. An overview of Korea's designated ATOs is provided in Table 1. This study's participants included third- and fourth-year university students as well as certified pilots attending plane and helicopter flying courses at three civil training institutions: the KAU, HU, and the Uljin Flight Training Center (Lee et al., 2015). Surveys were distributed to 1000 students between October 10 and 20 of 2010, and 120 valid and completed questionnaires were returned. An overview of the participants' demographic information is provided in Table 2.

Based on the perceptions of student pilots, we applied ANOVA (Analysis of Variance) along with exploratory factor analysis and partial least squares structural equation modeling (PLS-SEM). We tried to assess how risk factors affect accidents or incidents according to the SHELL framework. The survey (see Appendix) included 27 questions (L1 to L7, S8 to S12, H13 to H17, E18 to E22 and R23 to R27) related to SHELL as well as two questions (E28 and E29) related to outcome variables designed to gauge how participants' flight experiences and their institutions affected the student pilots' perceptions of accidents and other incidents.

2.1. Research hypotheses

Disconnects in communication between students and instructors occur frequently; this can be attributed in part to factors such as experience and motivation, although other elements are inherent to participants in a specific interaction (Hartman, 1995). Furthermore, learning styles differ between freshman, sophomore, junior, and senior students (Kanske and Brewster, 2001; Brady et al., 2001; Kanske et al., 2003), as well as according to the number of years of previous military flight training received (Carretta et al., 2014). The authors propose that a positive relationship exists between flight experience and risk factors within the SHELL interface model. Hence, the study's first research hypothesis (H1) is that with limited flight experience the impact on safety of all SHELL factors will be greater. This study categorizes three different groups using flying hours: Group 1 has less than 50 h, Group 2 has 51–100 h, and Group 3 has more than 101 h.

In recent years, several major transportation accidents have highlighted the role of organizational factors in motivating safety within high-risk systems (von Thaden et al., 2006). These

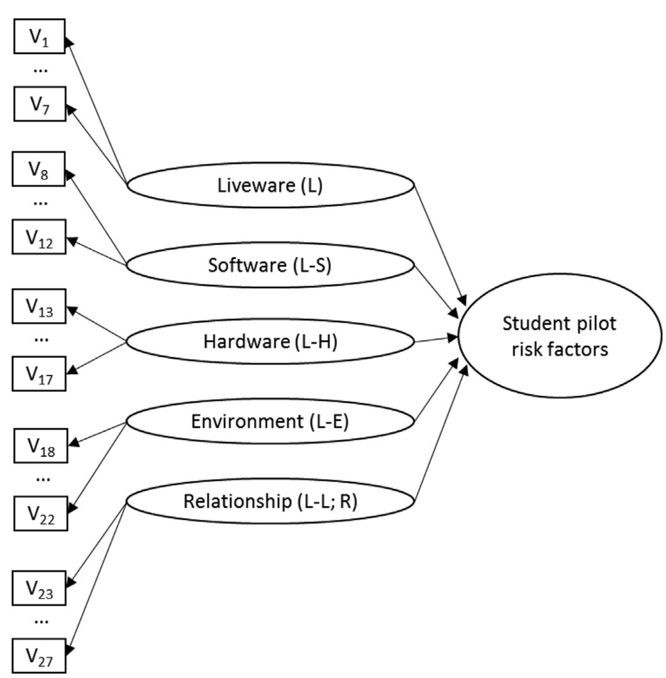

Fig. 1. Faults in the SHELL model related to human factors that contribute to incidents.

Table 1
Overview of Korea's ATOs.

Organization		Course type	Training period	Number of trainees (annually)
Civil	Korea Aerospace University (12 aircraft)	Private pilot	3 months	150
		Commercial pilot	9 months	90
		Instrument flight certificate	3 months	30
		Certified flight instructor	3 months	30
	Hanseo University (12 aircraft)	Private pilot	6 months	20
		Commercial pilot	12 months	40
		Certified flight instructor	3 months	20
Military	Air force (160 aircraft)	Commercial pilot	17 months (82 weeks)	120
		Commercial pilot (I)	72 weeks	50
		Commercial pilot (II)	3.5 months (15 weeks)	50
		Certified flight instructor	1 week	90
	Army (65 aircraft)	Commercial pilot	27 weeks	80
		Commercial pilot	13 weeks	50
		Instrument flight certificate	8 weeks	30
	Navy (59 aircraft)	Private pilot	22 weeks	30
		Commercial pilot	104 weeks (fixed) 160 weeks (rotational)	30
		Instrument flight certificate	10 weeks	50
		Certified flight instructor	8 weeks	25
		Private/commercial pilot	14 weeks	25
	Total	-	-	1100

Source: Ministry of Land, Transport, and Maritime Affairs, Office of Aviation, 2010 (Lee et al., 2015).

Table 2
Overview of participants' demographics.

Characteristics		Frequency	Percentage
Gender	Male	118	98.3%
	Female	2	1.7%
Affiliation	Fixed wing course	61	50.8%
	Helicopter course	21	17.5%
	General trainee	38	31.7%
Grade	Third year	41	34.2%
	Fourth year	41	34.2%
	General trainee	38	31.7%
Training course	Private pilot	93	77.5%
	Instrument flight	4	3.3%
	Commercial pilot	23	19.2%
Flying hours	1–50	61	50.8%
	51–100	31	25.8%
	101+	28	23.3%
	Minimum/maximum	1 and 182 h	
	Average/Std. Dev.	68/54 h	
	Coefficient of variation	0.794	
Total		120	100%

Source: Lee et al., 2015.

organizational factors consist of (1) the establishment of a safety culture (von Thaden, 2008) within an organization, including the implementation of regulatory oversight, such as maintenance and quality assurance procedures; (2) the norms, perceptions, values, and attitudes toward the aforementioned safety culture (Cooper, 2000); and (3) a stable training system that affords increased efficiency and effectiveness (Carretta et al., 2014), is based on instructional theory (Brady et al., 2001) and enhances the instructor's capability (Crow et al., 2011). Indeed, improper management and the deterioration of an organizational culture can lead to conflict or polarization between members in an institution. In this context, an organization's approach to pilot training will affect various risk factors differently. Thus, the study's second research hypothesis (H2) is that SHELL factors will affect safety differently according to the characteristics of each pilot's respective training institutions. Participants were divided into three groups based on training: with fixed wing for Group 1, rotate wing for Group 2, and general trainee, civil (KAU, HU) and military (Air Force, Army, Navy) for Group 3.

3. Results

An overview of the survey's findings is provided in Table 3 with mean, standard deviation, coefficient of variation (CV), and one-sample *t*-test results with *p*-values. Variables were measured using a 5-point Likert scale (1-definitely disagree, 3-neutral, 5-definitely agree). According to the one sample *t*-test results, all variables were statistically significant either positively[1] or negatively[2], with the exception of E19 (natural obstacles, mean (M)-value 3.16). A positive value means that respondents perceive that they have appropriate conditions (L2, 3, 5, 6), have the knowledge to fly (L–S), are equipped with appropriate instruments in the cockpits (L–H), are influenced by environmental factors (L–E), agree on the importance of the relationship with other crew, and have no experience with incidents (Ex 28) or accidents (Ex29). A negative value means the reverse of the positive value for each variable. The *t*-test is applied to learn the level of a student pilot's perception of risk factors in class and when flying. Respondents indicated that they lacked the ability to fulfill control procedures for each stage of a flight (L6; M-value 2.41), which could be because most students possessed only 68 h of flight experience on average, varying from 1 h to 182 h (Table 2). However, participants expressed that their knowledge (L4; M-value 2.44 and L5; M-value 2.77) was sufficient, despite occasionally experiencing physical or psychological instability (L2; M-value 3.36 and L3; M-value 3.31).

A mismatch was found in the L–S interface between S8 and S12, which could be attributable to the trainees' insufficient understandings of procedural knowledge, in addition to their misinterpretation of confusing documents, maps, and charts (Hawkins and Orlady, 1993). Likewise, the L–H interfaces were significantly mismatched, possibly due to improperly designed equipment, inappropriate or missing operational materials, poorly located or coded instruments, and faulty control devices and warning systems (Cacciabue, 2004). Based on the participants' demographics, it is reasonable to infer that the trainees lacked sufficient experience that would enable them to adapt to the cockpit environment.

[1] L2, L3, E20, E21, R23, R24, R25, R26, and R27.

[2] L1, L4, L5, L6, L7, S8–E18, E22, Ex28, and Ex29.

Table 3
One sample *t*-test results.

	Question subject	*M*	*SD*	*CV*	*p*
L	L1. Physical conditions	(−) 2.53	1.29	0.510	0.000**
	L2. Unstable mental or psychological conditions	(+) 3.46	1.04	0.301	0.000**
	L3. Poor physical conditions (e.g., fatigue or stress)	(+) 3.31	1.08	0.326	0.002*
	L4. Difficulty with technical abilities	(−) 2.44	0.99	0.406	0.000**
	L5. Inability to learn and/or an inadequate understanding of regulations	(−) 2.77	1.03	0.372	0.014*
	L6. Ability to fulfill flight-control procedures	(−) 2.41	0.79	0.328	0.000**
	L7. Personal issues (e.g., family, finances, or school problems)	(−) 2.73	1.10	0.403	0.007*
L-S	S8. Understanding and compliance with pilot's operating handbook	(−) 2.14	0.74	0.346	0.000**
	S9. Appropriateness of the training checklist	(−) 1.70	0.71	0.418	0.000**
	S10. Absence during the inspection period or missed checklist items	(−) 2.63	1.10	0.418	0.000**
	S11. Difficulty in preparing and/or understanding flight information data	(−) 2.13	0.81	0.380	0.000**
	S12. Use of automation equipment during training flights	(−) 2.66	0.95	0.357	0.000**
L-H	H13. Appropriate equipment, instruments, and displays in cockpit	(−) 2.13	0.70	0.329	0.000**
	H14. Display information easy to understand and clearly visible	(−) 2.18	0.71	0.326	0.000**
	H15. Adequate warnings and warning system	(−) 2.09	0.74	0.354	0.000**
	H16. Reliable cockpit equipment, instruments, and displays	(−) 2.01	0.64	0.318	0.000**
	H17. Comfortable seat positions and operation of flight gear	(−) 2.29	0.88	0.384	0.000**
L-E	E18. Temperature, humidity, and other factors	(−) 2.32	0.83	0.358	0.000**
	E19. Obstacles such as mountains, landmarks, birds, and other planes	3.16	1.05	0.332	0.100
	E20. Weather conditions	(+) 3.91	0.83	0.212	0.000**
	E21. Organizational culture	(+) 3.31	0.93	0.281	0.000**
	E22. Differences in power between oneself and flight instructors	(−) 2.94	1.10	0.374	0.563
L-L	R23. Effect of flight instructor on student performance	(+) 3.63	0.85	0.234	0.000**
	R24. Importance of relationships with other students	(+) 3.55	0.94	0.265	0.000**
	R25. Importance of relationships with air traffic controllers	(+) 3.77	0.88	0.233	0.000**
	R26. Importance of relationships with air mechanics	(+) 3.71	0.93	0.251	0.000**
	R27. Importance of relationships with flight support staff	(+) 3.74	0.80	0.214	0.000**
Exp.	Ex28. Mistakes that could have caused an accident or other incident	(−) 1.95	0.93	0.477	0.000**
	Ex29. Unstable conditions that could have caused an accident or incident	(−) 2.05	1.07	0.522	0.000**

+ denotes $M > 3$, − denotes $M < 3$, *$p < 0.05$, **$p < 0.001$.

As for the L–E interface, respondents did not report encountering difficulties in terms of temperature, humidity, atmospheric pressure, or vibration during training flights (E18; M-value 2.32), nor were they influenced by differences in power levels between themselves and their instructors (E22; M-value 2.94). However, weather (E20; M-value 3.91) and organizational culture (E21; M-value 3.31) were challenging factors. Physical obstacles such as mountains, landmarks, birds, and other planes (E19; M-value 3.16) did not pose a statistically significant amount of difficulty to those surveyed.

Interactions that occur between human operators during the performance of tasks involve (but are not limited to) relationships with maintenance and operations personnel (R26), engineers, designers, ground/flight/cabin crew (R27), air traffic controllers (R25), passengers, instructors (R23), students, managers, and supervisors (ICAO, 1993). These interactions can positively or negatively influence performance and the development of behavioral norms. The L–L interface focuses heavily on these interpersonal relationships from the perspectives of leadership, cooperation, coordination, communication, teamwork, culture, personality, attitude, and social dynamics (Hawkins and Orlady, 1993; Johnston et al., 2001). Although the respondents were inexperienced, they nevertheless understood the importance of interactions between human operators and other individuals in the aviation system, as their exposure to errors or unstable conditions that could potentially lead to accidents or other incidents was statistically significantly low (Ex 28; M-value 1.95 and 29; M-value 2.05).

A factor analysis was conducted to examine the SHELL interface model (see Table 4). In addition, normality, reliability, Kaiser-Myer-Olkin (KMO), and Bartlett's tests were conducted for factor analysis using all SHELL variables (Table 4). Each test produced suitable and homoscedastic results (i.e., diagonal P–P plots with expected cumulative probability and observed probability, a Cronbach's alpha exceeding 0.60, KMO score between 0.5 and 0.8, and test of homogeneity of variance through Bartlett's test score of 0.00). This was achieved, however, by eliminating E18 to obtain a Cronbach's alpha of 0.605 rather than 0.586. Extraction was performed by means of principal component analysis, while varimax rotation was used for the analysis itself. Factor analysis results for L convey information pertaining to pilots' capabilities (L4, L5, and L6) and flying conditions (L1, L2, L3 and L7); L–S involves the accuracy of flight data (S8, S9, S11 and S12) and checklists (S10); L–H focuses on cockpit equipment (H13 to H17); L–E concerns organizational culture (E21, E22), weather, and physical obstacles (E19, E20); and L–L addresses human relationships, both inside (R25, R26 and R27) and outside of the aircraft (R23 and R24). The factor analysis results were used to verify the study's research hypotheses and modify the research model from Figs. 1–2 and set the hypotheses shown in Fig. 2.

Regarding H1, correlations were identified between different flight experiences comparing Groups 1, 2, and 3. These indicate that less-experienced students are greatly affected by the non-physical support systems or software, such as rules and procedures. An average of 68 h of flying experience is not enough to learn the differences in flying conditions, individual capabilities, checklist compliance, and cockpit hardware, and to properly understand the relationships between instructors and other students (Table 5). As for H2, partial correlations were found between all measuring factors with organizations (civil and military; fixed wing, helicopter and general trainee course) and human factors. These factors include flying conditions, non-physical support systems, cockpit hardware, weather, and relationships between instructors and other students. Hence, the impact of organizational factors was greater than that of flight experience (Table 6). Given the aforementioned findings, H1 is rejected, and H2 is, to some extent, supported.

PLS-SEM was employed to determine the effects of risk factors on errors and other unstable variables that could potentially lead to accidents or other incidents and irregularities; reflective measurement was used to construct the model (Fig. 3). PLS-SEM

Table 4
Factor analysis results.

	Question subject	Fa. 1	Fa. 2	Cron. α	KMO/Bartlett's scores
L	L3. Physical conditions	**0.869**	−0.145	0.714	KMO = 0.793
	L2. Unstable mental or psychological conditions	**0.772**	0.279		Bartlett's
	L7. Personal issues (e.g., family, finances, or school problems)	**0.580**	0.298		χ2 = 198.052
	L1. Poor physical conditions	**0.521**	0.030		*df* = 21
	L4. Difficulty with technical abilities	0.134	**0.788**		Sig. = 0.000
	L6. Ability to fulfill flight-control procedures	−0.084	**0.767**		
	L5. Inability to learn and/or an inadequate understanding of regulations	0.468	**0.690**		
L-S	S8. Understanding and compliance with pilot's operating handbook	**0.787**	0.073	0.601	KMO = 0.649
	S12. Use of automation equipment during training flights	**0.743**	−0.110		Bartlett's
	S9. Appropriateness of the training checklist	**0.668**	0.081		χ2 = 89.632
	S11. Difficulty in preparing and/or understanding flight Information data	**0.650**	0.400		*df* = 10
	S10. Absent during inspection or missed checklist items	0.018	**0.963**		Sig. = 0.000
L-H	H14. Display information easy to understand and clearly visible	**0.831**	–	0.774	KMO = 0.767
	H13. Appropriate equipment, instruments, and displays in cockpit	**0.794**	–		Bartlett's
	H17. Comfortable seat positions and operation of flight gear	**0.686**	–		χ2 = 164.805
	H16. Reliable cockpit equipment, instruments, and displays	**0.675**	–		*df* = 10
	H15. Adequate warnings and warning system	**0.657**	–		Sig. = 0.000
L-E	E21. Organizational culture	**0.864**	0.061	0.605	KMO = 0.570
	E22. Differences in power between oneself and flight instructors	**0.795**	0.187		Bartlett's
	E20. Weather conditions	0.039	**0.872**		χ2 = 60.223
	E19. Obstacles such as mountains, landmarks, birds, and other planes	0.219	**0.791**		*df* = 6
					Sig. = 0.000
L-L	R26. Importance of relationships with air mechanics	**0.904**	0.011	0.714	KMO = 0.713
	R27. Importance of relationships with flight support staff	**0.882**	0.117		Bartlett's
	R25. Importance of relationships with air traffic controllers	**0.847**	0.188		χ2 = 194.188
	R23. Effect of flight instructor on student performance	−0.023	**0.836**		*df* = 10
	R24. Importance of relationships with other students	0.230	**0.756**		Sig. = 0.000

Bold indicates loading factor higher than 0.600 except for L.1.
Source: Modified of Lee et al., 2015.

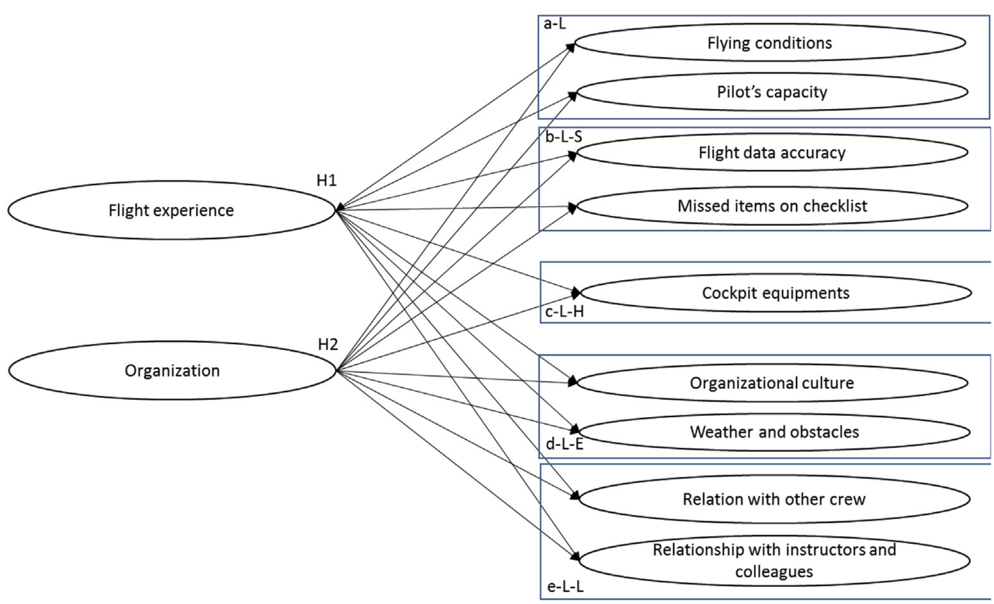

Fig. 2. Research model.

includes outer loadings (standardized weights) that are part of the relationships in reflective measurement models of the latent variables such as flying conditions, pilot's capabilities, and so on, to the indicators, L1 to R27 (Hair et al., 2014). The relationship between the dependent (E28, 29) and independent variables, with all other variables from L1 to R27 except 18, deleted after factor analysis (Table 4), was statistically not strong (R^2 = 0.318). This could be attributable to the fact that most participants lacked a great deal of flight experience and therefore had not encountered accidents or other incidents. Despite the limited significance of the aforementioned relationships, flight data accuracy (S8, 9, 11, 12) exhibited an influence on risk (*t*-value 0.243) with a significance level of 0.021. A lack of knowledge of operating handbooks, checklists and how to manipulate of automatic equipment, along with less preparedness regarding flight information, would significantly affect the risks during student pilots' flights.

Table 5
ANOVA results for H_1.

Hypothesis	Factor	Group	Mean	Post hoc tests			P	Support?
				1–2	1–3	2–3		
H_1. With limited flight experience the impact of L, S, H, E, and R on safety will be greater								
Impact of L on safety	Flying conditions	1	2.91	−0.014 (1.00)	−0.406 (0.072)		0.061	No
		2	2.92			−0.393 (0.166)		
		3	3.31					
	Pilot capabilities	1	2.65	0.279 (0.257)	0.145 (1.00)		0.216	
		2	2.37			−0.134 (1.00)		
		3	2.50					
Impact of L-S on safety	Non-physical support system	1	2.34	0.259 (0.099)	0.492 (0.000**)		0.000**	Yes, partially
		2	2.08			0.232 (0.315)		
		3	1.85					
	Ignoring checklist	1	2.49	−0.089 (1.00)	−0.508 (0.130)		0.122	
		2	2.58			−0.419 (0.427)		
		3	3.00					
Impact of L-H on safety	Cockpit equipment	1	2.18	−0.044 (1.00)	0.109 (1.00)		0.674	No
		2	2.14			0.064 (1.00)		
		3	2.07					
Impact of L-E on safety	Organizational culture	1	3.52	−0.048 (1.00)	−0.019 (0.130)		0.963	No
		2	3.56			0.028 (1.00)		
		3	3.54					
	Weather and/or terrain	1	3.07	0.041 (1.00)	−0.266 (0.532)		0.315	
		2	3.03			−0.307 (0.516)		
		3	3.34					
Impact of L-L on safety	Relationships inside aircraft	1	3.61	0.123 (1.00)	−0.072 (1.00)		0.574	No
		2	3.48			−0.194 (0.914)		
		3	3.68					
	Relationships outside aircraft	1	3.67	−0.355 (0.108)	0.083 (1.00)		0.053	
		2	4.02			0.438 (0.086)		
		3	3.58					

Note: Group 1: less than or equal to 50 h, 2: between 51 h and 100 h, and Group 3: more than 101 h of flight time.
$^{*}p < 0.05$, $^{**}p < 0.01$.

Table 6
ANOVA results for H_2.

Hypothesis	Factor	Group	Mean	Post hoc tests			p	Support?
				1–2	1–3	2–3		
H_2. L, S, H, E, and R will affect safety differently according to the characteristics of each pilot's respective organization								
Impact of L on safety	Flying conditions	1	3.25	0.551 (0.014*)	0.484 (0.007*)		0.002*	Yes, partially
		2	2.70			−0.067 (1.00)		
		3	2.77					
	Pilot capabilities	1	2.52	0.154 (1.00)	−0.147 (0.995)		. 307	
		2	2.37			−0.301 (0.398)		
		3	2.67					
Impact of L-S on safety	Non-physical support system	1	2.03	0.209 (0.440)	0.293 (0.041*)		0.037*	Yes, partially
		2	2.24			−0.084 (1.00)		
		3	2.32					
	Ignoring checklist	1	2.80	0.470 (0.276)	0.277 (0.668)		0.185	
		2	2.33			−0.193 (1.00)		
		3	2.53					
Impact of L-H on safety	Cockpit equipment	1	2.02	−0.209 (0.356)	−0.275 (0.038*)		0.032*	Yes
		2	2.23			−0.066 (1.00)		
		3	2.29					
Impact of L-E on safety	Organizational culture	1	3.60	0.074 (1.00)	0.164 (0.962)		0.608	Yes, partially
		2	3.52			0.089 (1.00)		
		3	3.43					
	Weather and/or terrain	1	3.32	0.272 (0.608)	0.464 (0.025*)		0.028*	
		2	3.05			0.192 (1.00)		
		3	2.86					
Impact of L-L on safety	Relationships inside aircraft	1	3.62	−0.138 (1.00)	0.175 (0.720)		0.248	Yes, partially
		2	3.76			0.314 (0.332)		
		3	3.45					
	Relationships outside aircraft	1	3.64	−0.472 (0.046*)	−0.054 (1.00)		0.047*	
		2	4.11			0.418 (0.134)		
		3	3.69					

Note: Group 1: Fixed wing majorly in KAU and HU, 2: Helicopter course majorly in military organization, and Group 3: General trainees in civil and military organizations.
$^{*}p < 0.05$, $^{**}p < 0.01$.

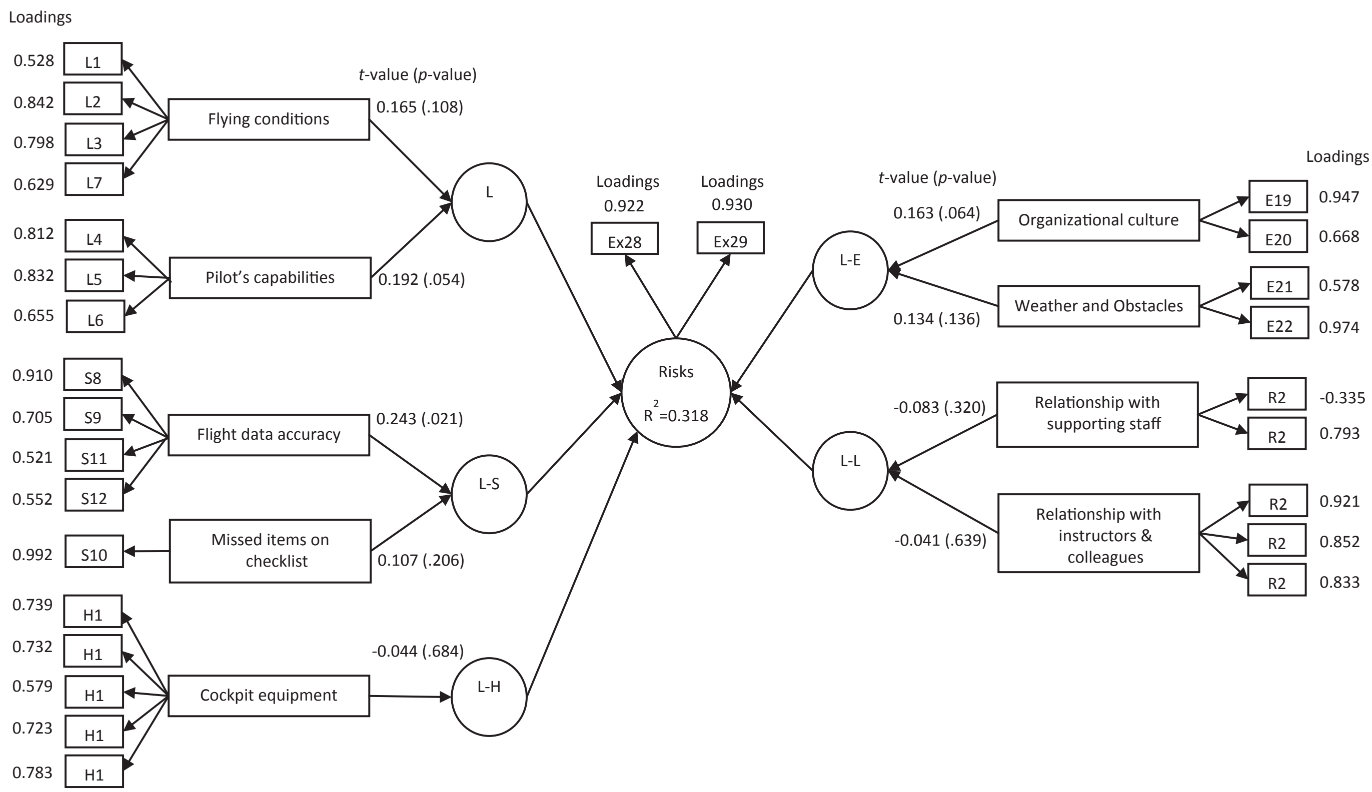

Fig. 3. PLS-SEM research model and results.

4. Discussion

Human elements—including flight, cabin, ground crew, pilots, management, and administrative personnel—are included in the SHELL interface model as part of the liveware component, which accounts for human performance, capabilities, and limitations (ICAO, 1993). Despite trainees completing courses encompassing interactions with hardware, software, and supporting staff, they were not well prepared for flights (Table 3). Furthermore, the participants did not generally perceive the importance of the relationships between air traffic controllers, mechanics, and other individuals involved in the flight process. This is problematic given that aviation accidents are generally caused by a series of errors that originate from multiple risk factors (Javaux, 2002). In addition, organizational differences exist in interactions between hardware, software, and personnel capabilities because implementation methods and program content can vary significantly according to the unique circumstances of each entity's training environment. Indeed, training paradigms may even differ between military, civil, offline, and online-oriented ATOs. Moreover, organizational culture exhibited a significant effect on flights due to differences in power between instructors and students; these differences were evident in human interactions inside aircrafts. Organizations that emphasize safety are able to adapt to various situations and devise coping mechanisms upon encountering problems; these approaches begin at an organization's highest levels and subsequently trickle down to front-line workers (von Thaden et al., 2006).

Standardized programs should be implemented to improve ATOs as they adapt to meet an increasing demand for pilots; this entails the enactment of appropriate oversight and evaluation by relevant authorities. The aviation industry's rapid expansion in the Asia-Pacific region, especially in China and the Middle East, will inevitably lead to the establishment of numerous ATOs and should result in increased concerns for safety and the promoting of human factors, especially the relationships with not only instructors and other pilots but also other relevant persons including ground crews, air traffic controllers and others (L-L). Undoubtedly, interactions between human factors and other aspects affect aviation safety; these include L–H interactions (i.e., those between man and machine) and L–L interactions (i.e., those between an instructor, mechanic, and controller). Naturally, a student pilot's physical and psychological conditions and behavior (e.g., negligence of duty, failure to obey standard operating procedures, and inappropriate actions) also adversely affect aviation safety (Reason, 1990; Hawkins and Orlady, 1993; Peterson, 2001). This will require ATOs to improve, standardize, and continue to develop their curricula in order to maintain a high quality of training to avoid irregularities.

5. Conclusion

This research examined the relationship between students' flight experience and the ATOs they attended on their perceptions of risk factors from a statistical perspective. The results revealed that a lack of flight knowledge among students attending recently opened ATOs exhibited a moderating influence. The increased demand for pilots in Korea and China will ultimately lead to more flights and, consequently, a greater risk for accidents. For example, in 2011, a newly opened ATO in Korea experienced a fatal accident within its first year of operation, wherein two training aircraft collided in midair. Likewise, in 2013, an accident occurred in the same area that resulted in three fatalities, including an instructor.

Graduates from collegiate aviation programs bring with them a new safety culture upon beginning their operational occupations; hence, emphasizing safety during training should lead to positive changes in the safety cultures of aviation-related organizations. Aviation standards have changed continuously since World War II, and safety measures have evolved similarly (De Voogt and

D'Oliveira, 2012). Deregulation has not resulted in decreased flight activity or reduced air safety; in fact, it has caused greater emphasis to be placed on safety practices (Morrison and Winston, 1988; Raghavan and Rhoades, 2005). Future research should examine the training practices of established and recently established military and civilian ATOs in order to identify any possible differences between them. In addition, subsequent studies should attempt to identify the causes leading to problematic interactions between software, hardware, and supporting staff in light of course syllabi, instructor capabilities, and organizational cultures.

Appendix. Survey questions (Lee et al., 2015)

Liveware (L)

L1. During training flights, I have been influenced by physical conditions such as strength, height, arm length, eyesight, hearing, and lack of stamina.
L2. I have never conducted training flights in a mentally unstable condition wherein anxiety, lack of confidence, or lack of preparation were factors.
L3. During training flights, I have never been affected by physical conditions such as fatigue, lack of sleep, intoxication, or stress.
L4. I experience difficulty conducting training flights given my current technical abilities.
L5. I have never experienced difficulty conducting training flights due to an inability to learn or an inadequate understanding of regulations.
L6. My capabilities are sufficient enough to carry out each stage of the flight-control procedures.
L7. During training flights, I am occasionally influenced by personal issues, such as family, finances, or school problems.

Liveware-software (L-S, S)

S8. I understand and comply with the pilot's operating handbook, which is used for training flights.
S9. The training checklist includes useful procedures regarding the sequence of flight requirements, which are applicable both inside and outside of the cockpit.
S10. I have never been absent during inspections nor missed any items on the training checklist.
S11. During training flights, I experience difficulty preparing and understanding flight information (e.g., charts, approach procedures, weather information, and notices to airmen).
S12. I am aware of how and when to use the automation equipment available during training flights.

Liveware-hardware (L-H, H)

H13. The cockpit's structure and the layout of equipment, instruments, and displays are appropriate.
H14. Pilots can clearly see and easily understand what is shown on the displays.
H15. The warning systems provide sufficient information to maintain safety and take appropriate actions.
H16. The equipment, instruments, and displays in the cockpit are reliable.
H17. I am comfortable adjusting seat positions and operating flight gear (e.g., the control stick, rudder, and trim).

Liveware-environment (L-E, E)

E18. I experience difficulty conducting training flights due to factors such as temperature, humidity, atmospheric pressure, and vibration.
E19. Physical obstacles such as mountains, landmarks, birds, or other planes have affected me during flights.
E20. I have been influenced by weather conditions during flights.
E21. I have been influenced by organizational culture (e.g., work atmosphere, miscommunication, or poor teamwork) during flights.
E22. I have been affected by differences in power between myself and flight instructors.

Liveware-liveware (L-L, R)

R23. Student performance is dependent on flight instructors during training flights.
R24. One's relationship with other students during training flights is important.
R25. One's relationship with air traffic controllers during training flights is important.
R26. One's relationship with air mechanics is important, both before and after a flight.
R27. One's relationship with flight support and other staff members is important, both before and after a flight.

Experience (Exp., Ex.)

Ex28. I have never made a mistake that could have led to an accident or other incident.
Ex29. I have never encountered an unstable situation that could have led to an accident or other incident.

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