
AVIATION SYSTEM SAFETY AND PILOT RISK PERCEPTION: IMPLICATIONS FOR ENHANCING DECISION-MAKING SKILLS

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ABSTRACT

This research explores risk perception in a defined population of flight instructors and the implications of these views for flight training. Flight instructors and students engaged in collegiate aviation flight training were interviewed for this qualitative study. Thirty-three percent of the instructors interviewed reported that flying is not a risky activity. This is important because research identifies risk perception as one factor influencing instructional choices. These choices can then impact the subsequent decision-making processes of flight students. Facilitating pilot decision-making through the use of an appropriate type of learning that incorporates the modeling of consensually validated cognitive procedures and risk management processes is discussed.

Issues of safety are of paramount importance in the field of aviation. The Federal Aviation Administration's *Safer Skies* initiative (1998), for instance, is a primary vehicle for addressing issues of safety. One goal of this initiative is to achieve "a significant reduction of general aviation accidents and fatalities" (p. 1). To accomplish this goal for general aviation, the initiative suggests an emphasis on pilot decision-making as well as loss of control, weather, controlled flight into terrain, survivability, and runway incursions.

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Flathers, Giffin, and Rockwell (1982) studied decision-making behavior of pilots facing a deviation from a planned flight. They found that differences in decision-making related to several factors, including grade of pilot certificate, the amount and type of initial and recurrent training, and the type of flying most commonly done. In this study, they found that pilot training affected subsequent decision-making and suggested that “A closer examination of the training and certification process is in order” to improve pilot decision-making (Flathers et. al., 1982, p. 963). O’Hare and Roscoe (1990) also state that “Most national and international aviation organizations are increasingly accepting the position that flight training, particularly in general aviation, is a problem” (pp. 61–62). They continue that to increase safety, more attention needs to be paid to the judgmental education of professional pilots in addition to the traditional emphasis on training in skills and procedures.

What is the best way to teach good pilot decision-making skills? One way, suggested by Bandura (1986), is by using strategies which take into account the amount of risk involved with aviation. A study by Green (1998) suggests that instructional choices can be influenced by the degree to which flight instructors perceive an activity as high-risk. The instructional choices made by the flight instructors can then impact subsequent decision-making processes of their students. This research explores factors that affect risk perceptions, the perceptions of risk identified in a defined population of flight instructors, and the implications of these views on aviation training.

BACKGROUND

Risk Perception

It is obviously important to understand those factors which influence the practitioner’s perception of risk and to determine whether prevailing attitudes among flight instructors identify the activity as being high-risk in nature. High-risk is defined for these purposes as the potential in an activity for loss of life or limb, litigation, loss of reputation, and/or expenditures of large amounts of money if a pitfall or in-flight problem is mishandled.

Thompson (1993) explores risk perception. She proposed that principles of realism, optimism, and flexibility affect the amount of personal control experienced and the adaptiveness of naturally occurring perceptions of control. She stated that: “In considering how people judge the control available to them, it appears that people often have optimistic estimates of their control that focus on what they can influence, downplay the areas where control would be difficult, and overestimate the likelihood of their influence being successful” (Thompson, 1983, p. 89). Thompson also states that even when people do not feel they can exert primary control, they

maintain perceived control by trusting in the ability of others to help them (secondary control). Reliance by a pilot on ATC to avoid weather or other problems is an example of this. Thompson stated in explaining “bounded flexibility” that: “Many people seem to overestimate their potential for influence, but judgments of personal control are also responsive to objective limits and subjectively perceived constraints on an individual’s influence” (Thompson, 1983, p. 89). Boundaries are thus provided to these individual perceptions.

Wickens (1992) states that “people’s perception of risk seems to be guided by the availability of examples of the risky event in long-term memory” (p. 294). He cites the work of Slovic, Fischhoff, and Lichtenstein (1981) that reports certain risks are considerably overestimated while others are greatly underestimated by people and that “perceived risks are directly correlated with the amount of publicity that the varying hazards receive in the media” (p. 294). Wickens also reports that personal experience plays a role in availability and the estimated risks of an activity decreases for people who have had accident-free experience with an activity (Karnes, Leonard, and Rachwal, 1986 cited in Wickens, 1992, p. 294). Personal experiences may be misleading, however. Pilots with no personal encounters with “pitfalls” in training or in flight may therefore not consider either aviation in general or a specific task to be a risky activity.

Slovic (1987) states that “those who promote and regulate health and safety need to understand the ways in which people think about and respond to risk” (p. 280) and that this information can be used to direct educational efforts. Douglas and Wildavsky (1982) cited in Slovic (1987) assert that “people, acting within social groups, downplay certain risks and emphasize others as a means of maintaining and controlling the group” (p. 281). Slovic (1987) states that “when experts judge risk, their responses correlate highly with technical estimates of annual fatalities” (p. 283) but that “expert’s judgments appear to be prone to many of the same biases as those of the general public” (p. 281). He reports that lay people may have differing evaluations of the risk of an activity because of the use of a different definition of risk that may include, for instance, catastrophic potential. Slovic (1987) exemplifies this variation in a table that quantifies the perceived risk by different groups for 30 activities. General aviation is ranked as the seventh riskiest activity by the League of Women Voters, and is ranked twelfth riskiest of the listed activities by aviation experts.

Risk in General Aviation

Accident analyses indicates that “during the four years 1989–1992, 1226 instructional airplanes were involved in 1218 crashes included in the National Transportation Safety Board files. The casualties included 250

deaths, 128 serious injuries, and 270 minor injuries” (Baker, Lamb, Li, and Dodd, 1996, p. ix). For the six years 1991–1996 the Nall report (1997, p. 3) reports a total of 10,811 U.S. General Aviation accidents. These included 1,906 fatal accidents with 4,065 fatalities. Aviation is a high-risk activity.

The Nall Report (1997) states that just because there are risks in an activity it does not mean that harm is inevitable. The Nall report also states, however, that pilots cannot afford to ignore the risks involved in aviation simply because they are inherent in the activity. The goal is to “gain knowledge about the risks and take proactive steps to control them” (Nall Report, 1997, p. 2). The first step is acknowledging the risk in aviation and then enhancing decision-making skills in order to manage them effectively. This research explored how flight instructors perceive risk in general aviation.

METHODOLOGY

This paper presents qualitative data collected from private and instrument flight instructors and students teaching and learning in collegiate aviation programs. The data presented here are those used in previous research (Green, 1998) addressing learning through flight simulation. Dimensional sampling (Arnold, 1970) was used to identify participants in the study. According to Arnold, dimensional sampling involves three steps. In the first step, the universe to which you eventually want to generalize is explicitly delineated. In the second step, what appear to be the most important dimensions along which the members of this universe vary and develop are spelled out. A typology is also developed that includes the various combinations of values of these dimensions. In step three, this typology is used as a sampling frame for selecting a small number of cases from the universe.

This type of sampling allows a researcher to avoid limitations that would be experienced in either a single-case study or a large-number approach to a topic. This sampling technique seeks to minimize systemic variance and maximize potential diversity.

Systemic variance in this study was minimized by selecting potential respondents only from the population of those using flight/aviation training device (F/ATD's) as part of a college or university based flight program. This is one segment of the general aviation community flight training community. A survey by the University Aviation Association (1991) found that training devices were in use in this segment of the aviation community.

Diversity was maximized by identifying the following four dimensions for sampling purposes:

1. The type of certification F/ATD training was used for: The two types of certifications addressed in this dimension were
 - (a) Private Pilot Certification; and
 - (b) Instrument Pilot Certification.
2. The type of instructor qualifications: Types of instructor certification addressed were
 - (a) Certificated Flight Instructors (CFI's); and
 - (b) Certificated Instrument Flight Instructors (CFII's).
3. The type of simulation technology:
 - (a) Flight training devices; and
 - (b) Personal Computer-Based Aviation Training Devices
4. The type of higher education institution:
 - (a) University;
 - (b) College; and
 - (c) Community College

The qualitative, exploratory principle of saturation was used to determine the actual number of interviews and observations (Merriam, 1988). According to the principle of saturation the time to stop collecting further data from observations or interviews is when additional data is unlikely to differ from what has already been obtained because the last few observations or interviews have contributed little or no new information.

Individual interviews of flight instructors and students were conducted both in person and by telephone. A total of 25 interviews were conducted with the following types of persons: Certificated Flight Instructors; Certificated Instrument Flight Instructors; primary flight students; and instrument flight students. The distribution of field interviews according to type of institution is presented in Table 1. The distribution of field interviews according to type of interviewee is shown in Table 2.

Table 1. Distribution of Field Interviews According to Type of Institution

<i>Type of institution</i>	<i>Number of institutions in which interviewing was conducted</i>	<i>Number of interviews</i>
Universities	5	23
Colleges	1	1
Community Colleges	1	1
Total	7	25

Table 2. Table Distribution of Field Interviews According to Type of Interviewee

<i>Type of interviewees</i>	<i>Number of interviews</i>
Instrument instructors (CFII)	12
Primary instructors (CFI)	3
Instrument students	6
Primary students	4
Total	25

Nine of the fifteen instructors interviewed (CFI and CFII) were from the same university based program. These nine instructors were also observed giving instruction in a training device. The students who were involved in these observations were also interviewed. In other words, each student interviewee was explicitly linked to one of the nine instructors in this subset and was also the subject of observation. In one case, two observations were performed of one instructor and both students observed were then also interviewed. This resulted in a total of ten student interviews and observations. All of the students interviewed had been exposed to the influences of at least two instructors (ground and flight).

Using instructor interviews and student interviews from one academic program resulted, through purposive sampling, in the inclusion of instructors with different experience levels and maximum diversity. Since the object of the research was not to explore diversity solely within the tradition of one flight program (Ruesch, 1975, pp. 49-57), other schools were chosen through systematic selection from a listing of college-based aviation flight programs (UAA, 1991). The department heads of these schools then nominated an individual to take part in the research.

RESULTS

In response to an interview question, 73 percent of flight instructors initially indicated that they do not consider flying a risky activity. When the question was reframed pointing out specific potential flight hazards, the percentage indicating that they did not consider flying to be risky declined, although 33 percent of the instructors still maintained that flying is not a risky activity.

Do You Consider Flying to Be a Risky Activity?

Interviewees seemed strongly partisan to seeing flying either as safe or risky. Students and instructor responses both included strong denials that flying was risky. Overall, the majority of respondents (68 percent) indicated flying was not risky; that it was safe (Table 3). Among instructors, 73 percent reported that flying was not risky (that it was safe). Included in

Table 3. Summary of Responses: Do You Consider Flying to Be a Risky Activity?

	<i>Risky</i>	<i>Safe</i>	<i>Total</i>
Instructors	4 (27%)	11 (73%)	15
Students	4 (40%)	6 (60%)	10
Total	8 (32%)	17 (68%)	25

this 73 percent figure are 17 percent (2) who stated that risk depended solely on pilot actions (see Appendix A). Among students, 60 percent indicated that flying was not risky (see Appendix B).

Engaging in this type of risk denial can result in an instructional design process that completely bypasses the need to address pitfall management. Risk denial allows practitioners to view flight as merely the implementation of technical procedures that, if done correctly, eliminate the potential for risk and downplay the role of good pilot judgement. This question turned out to be essential in helping the researcher understand the interviewee's frames of reference pertaining to their view of the aviation environment.

Leaving the interview at this level, however, was not found to be sufficient. Using the "funnel sequence" (Cannell and Kahn, 1968) helped interviewees reconsider their way of explaining their view of safety and risk in aviation. According to Cannell & Kahn (1968): "Within a subject area, the sequence of questions should be such as to lead the respondent meaningfully through the process of exploration. Often this can be done by means of the 'funnel sequence,' which proceeds from the broadest and most open of questions to the most specific" (p. 571). The question was reframed and asked again.

Can Loss of Life or Limb, Litigation, Loss of Reputation, and/or Expenditure of Large Amounts of Money Result if You Mishandle a Pitfall or Encounter Untoward Events? If Yes, Please Give an Example

With the reframing of this question 33 percent of the instructors still insisted flying is not a risky activity (see Appendix C). The majority of overall respondents (72 percent) did agree that these forms of risk were possible (Table 4). Among flight instructors there was 67 percent agreement and among students (see Appendix D) there was 80 percent agreement that these risks could occur. The flight instructors and students who initially indicated that they considered flying risky were included in the "Yes" category of this answer.

Pitfalls that were identified by interviewees included engine problems, wind shear, mechanical problems, and pilot error such as mistuning navigation radios and misreading altimeters. One instructor mentioned the

Table 4. Summary of Responses: Can Loss of Life or Limb, Litigation, Loss of Reputation, and/or Expenditure of Large Amounts of Money Result if You Mishandle a Pitfall or Encounter Untoward Events? If Yes, Please Give an Example

	<i>Yes</i>	<i>No</i>	<i>Total</i>
Instructors	10 (67%)	5 (33%)	15
Students	8 (80%)	2 (20%)	10
Totals	18 (72%)	7 (28%)	25

American Airlines accident in Cali, Colombia as an example of a risk resulting from mistuning a navigation radio and related a similar error made by his student.

There is defensiveness to the responses of those who exhibit radical denial of risk, almost protective of aviation, refuting the traditional view of aviation as a daredevil activity. One person said that aviation only appeared risky to people outside the profession. While aviation may not be a “daredevil” activity, it is not realistic to deny all risk.

DISCUSSION

Whether instructors recognize risk in aviation cannot be overestimated when considering the type of learning that is appropriate for an activity. According to Bandura (1986) any type of learning: autonomous; guided inquiry; reception (all described by Ausabel, Novak, and Hanesian, 1978); or social-cognitive (Bandura, 1986) is appropriate for low risk endeavors. When an activity is safe there are no adverse consequences to implementing any type of learning.

If aviation is viewed as primarily a high-risk activity (the potential exists for loss of life or limb, litigation, loss of reputation, and/or expenditures of large amounts of money if a pitfall is mishandled) then instructors need to operate with the understanding that any form of trial-and-error learning is contra-indicated because of the potentially catastrophic consequences. Bandura (1986) states that

one does not teach children to swim, adolescents to drive automobiles, and novice medical students to perform surgery by having them discover the requisite behavior from the consequences of their successes and failures. The more costly and hazardous the possible mistakes, the heavier must be the reliance on observational learning from competent exemplars.... (p. 20)

Bandura characterizes risk as a condition that precludes the use of autonomous learning or guided inquiry, both of which have a self-directed component. A method of learning which allows socialization to the “gold standards” of the field (acceptable routines that have been constructed and consensually validated by a profession to handle specific types of situations) is appropriate under these conditions.

Cognitive apprenticeship was developed by Collins, Brown, & Newman (1989). It is a form of social-cognitive learning which has as been operationalized for use in socializing learners to proficient practice in high-risk professions (Brandt, Farmer, & Buckmaster, 1993; Farmer, Buckmaster & LeGrand, 1992). Cognitive apprenticeship starts with a type of situation and models an acceptable way of performing that has been constructed and consensually validated by the field. The purpose is to socialize learners to a cadre of people in the same occupation and to have them proficiently deal with types of problems using procedures that are accepted by a particular field of practice. Table 5 outlines the five phases of cognitive apprenticeship. Integral to cognitive apprenticeship is the explicit inclusion of validated risk management processes

IMPLICATIONS

The challenge before us is to increase aviation safety through the improvement of pilot judgement and decision-making. It is recognized that even highly experienced and well trained commercial flight crews sometimes make decisions when dealing with unplanned events that in retrospect are nearly inexplicable. The accident analysis for AA Flight 965 near Cali Columbia (Aeronautical Civil of the Republic of Columbia, 1996) is a case in point. This accident was a controlled flight into terrain caused primarily by a change of course, based on guidance from a mistuned radio, that was made without first verifying the effect on flight path. The accident report states in part that “although the accident flight crew articulated misgivings several times during the approach, neither pilot displayed the objectivity necessary to recognize that they had lost situation awareness,” the descent was not discontinued, and a climb was not initiated in time to avoid terrain. The analysis notes that one explanation of the crew’s actions is that “the guidance given in the in the airline reference guide and in training did not have sufficient impact to be recalled in times of high stress and workload,” and that the crew “did not recognize the hazards the airline had warned them about” (pp. 36–37).

This research demonstrates that pilot attitude toward risk and risk management strategies are established quite early in flight training. The first step to risk management is the recognition of risk. Fully a third of the flight instructors interviewed did not recognize the risk inherent in aviation, assuming competence in routine procedures will suffice in achieving an accident-free career. The emphasis on criterion-referenced performance standards i.e., maintenance of +/-100 feet in maneuvers, in the FAA Practical Test Standards may contribute to this view. The pilots of AA 965, in terms of “bounded flexibility,” displayed an optimistic estimate of their

ability to complete the approach, downplayed the areas where control would be difficult, and overestimated the likelihood of their influence being successful.

This research also suggests that pilot decision-making can be facilitated through the use of an appropriate type of learning that incorporates the modeling of consensually validated cognitive procedures and risk management processes. Not just content, but how that content is taught in the early stages of pilot training, can have important implications for the development of risk management strategies in pilots. The accident analysis of AA 965 states that the pilots were not able to apply what they had learned simply from reading or hearing about the approach conditions. The robustness of cognitive apprenticeship for aviation instruction is validated

Table 5. Phases of Cognitive Apprenticeship

<i>Phase</i>	<i>Role of Learner</i>	<i>Role of Model</i>	<i>Key Concepts</i>
Phase I	Observes performance of activity, not merely the subskills. Develops mental model or schema of what the real thing looks like.	Models an acceptable procedure. Model states aloud: principles underlying the procedure; tricks that make it work; and identifies pitfalls likely to be incurred and how to handle them.	Articulation Domain specific heuristics Situated knowledge Schema
Phase II	Approximate doing the real thing and articulate its essence. Reflect on the model's performance. Use self-monitoring and self-correction	Provide coaching to the learner. Provide support when needed.	Scaffolding Coaching
Phase III	Continue to approximate the real thing. Work individually or in groups.	Decrease scaffolding and coaching	Fading
Phase IV	Practice doing the real thing on his/her own. Do so within specified limits acceptable to profession and society.	Provide assistance only when requested.	Self-directed learning
Phase V	Discuss the generalizability of what has been learned	Explain the generalizability of what has been learned and provides an advance organizer.	Generalizability

Note: By J.A. Farmer, 1996. Adapted with permission of the author.

in that it either includes or addresses all seven important training factors identified by Wickens (1992). These factors are: (a) practice and overlearning; (b) elaborative rehearsal; (c) reducing concurrent task load; (4) error prevention; (5) adaptive training; (6) part-task training; and (7) knowledge of results.

In training competent pilots we must teach not only for the overwhelming majority of flight time that is routine but also for those instances that distinguish aviation as a high-risk endeavor. The learner must be able to do routines but also handle problems in ways that work for the individual pilot and are appropriate under the circumstances while being in compliance with the regulations, rules, procedures, and principles of aviation. The training to achieve this, which will impact pilots throughout their careers, needs to be incorporated in the early stages of flight training. If and how we adapt our educational practices to enhance pilot decision-making will have important implications for aviation safety in the future.

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APPENDIX A

Instructor Responses: Do You Consider Flying to Be a Risky Activity?

- "I don't consider flying risky if you know what you are doing."
- "I don't feel every day I go up and take my life in my hands."
- "I don't consider it any riskier than any other activity. I risk my life when I wake up and get out of bed."
- "No, not at all risky."
- "I don't consider flying to be adversely risky. If you are riding a bike there is risk"
- "I don't think flying is risky."
- "I never feel like flying is risky."
- "It is no riskier than boating."
- "I don't feel like it is risky, but I am so used to it I might as well be getting in my car."
- "I guess it depends. If I were to do something stupid like fly in icing conditions it would be risky. Most of the time I feel I am in control of the situation, whether I am flying by myself or with a student."
- "Yes, I do consider flying risky, but I also deliver pizzas and I find that driving to have the same risk level."

APPENDIX B**Student Responses: Do You Consider Flying to Be a Risky Activity?**

“I think flying is very safe.”

“I consider driving a car more risky than flying.”

“There is less risk than most activities.”

“There is not too much risk.”

“No I do not consider it risky.”

“No (it’s not risky) because technology has advanced. The main concern of everyone while flying is having an engine failure. And the technology that new engines use today is so far advanced that engine failures are very rare. Almost every other risk you can prevent yourself.”

“I do consider it risky but no more so than driving.”

“I’m not sure it’s risky but it is scary.”

“From what I have heard, it is risky.”

“In a way I think it is. It’s riskier than many other occupations but it is also risky being a police officer. (In aviation) not only is your life in danger, but you are putting in so much money and if you fail a class there are additional costs. So you have to take it more seriously. We really have a lot of responsibility. In that respect, I think it is a pretty dangerous occupation, but if you have developed a how-to-be-responsible attitude you can avoid a lot of the hazards.”

APPENDIX C**Instructor Responses: Can Loss of Life or Limb, Litigation, Loss of Reputation, and/or Expenditure of Large Amounts of Money Result if You Mishandle a Pitfall or Encounter Untoward Events?**

“I don’t agree with that statement.”

“(This definition) doesn’t change my answer. I don’t find aviation risky. If you’re riding a bicycle there’s always a potential for catastrophe.”

“No, bad luck is created by people and if you have competent people that lessens the potential risk factor.”

“My answer stays the same, no, aviation is not risky.”

“No, mechanical problems and engine failures could be risky, but if you know how to take care of (them) I don’t consider them very risky.”

“I have enough confidence in myself and my students (to prevent) risks.”

“If you are looking at one mistake and there goes my ticket then I would definitely consider it higher risk.”

“The potential is always there.”

“I think so. I agree with that.”

“Most certainly.”

APPENDIX D**Student Responses: Can Loss of Life or Limb, Litigation, Loss of Reputation, and/or Expenditure of Large Amounts of Money Result if You Mishandle a Pitfall or Encounter Untoward Events?**

“I think most of the risk comes at the point where the accident chain is advancing and the pilot doesn’t realize it, something goes wrong, and the risk all of a sudden just explodes.”

“Considering that most flights are very safe, there are few that crash, it really doesn’t change my mind (aviation is safe). Only a very small percentage have problems.”

“It has more risk than other things you could be doing but there’s a lot of things that are more risky, like being a police officer. So I think the chances are better that those things aren’t going to happen.”