A PEDAGOGICAL APPROACH TO TEACH AVIATION STUDENTS HOW TO CONDUCT SITUATION AWARENESS RESEARCH

Andrew R. Dattel
Andrey Babin
Tianhua Li
Ziyi Dong
Stephanie G. Fussell
Qianru Yang
Embry-Riddle Aeronautical University
Daytona Beach, FL

Situation awareness (SA) has been investigated in the aviation industry for decades and recently has become more prominent in other industries. For example, healthcare has experienced tremendous growth in SA research and training. Despite agreement among researchers that SA is important for performance and safety in complex domains, less agreement exists for defining and measuring SA. Certain industries (e.g., aviation, healthcare, process control operations) often have specific methods on how to approach SA. These approaches of introducing employees and students to SA in a specific context may inadvertently limit their full appreciation and understanding of this construct.

To address this issue, graduate students with a wide variety of aviation interests were enrolled in a course titled, "Situation Awareness in Aviation/Aerospace." Common theories and applications of SA were discussed throughout the course. To increase their domain-general understanding of SA, students completed both aviation and non-aviation assignments. An example of the latter included giving individual presentations of National Transportation Safety Board (NTSB) reports of non-aviation accidents. Also, as a group project, students collected SA data from human participants in a non-aviation dynamic environment. Students responded favorably to these activities and reported that learning about SA in other environments gave them a better understanding and appreciation of SA. This paper discusses the steps taken to teach SA, the outcome measures of the class, and the unique perspective that students had of learning about SA outside of aviation. Feedback from students highlights the benefits of cross-domain pedagogical approaches to teaching SA.

The traditional college classroom is changing. Instead of only presenting a traditional one direction lecture approach, many college professors seem to be offering additional pedagogical approaches such as active learning, engaged learning, and learning via application to many domains (Barkley, 2010; Lee, 2004). Graduate students enrolled in a summer term *Situation Awareness and Performance* seminar in an aviation program studied the theories of situation awareness, but learned and applied situation awareness in both an aviation and non-aviation context. This seminar where students were more active in the pedagogical approach, as well as developing a respect for situation awareness outside of their comfort zone (i.e., aviation) proved to be not only a rewarding experience, but an effective learning experience as well.

Situation Awareness

Those in aviation may experience nostalgia when they remember the aircraft hangar talks when the term situation awareness (SA) became commonly accepted. Pilots would sit around and try to explain accidents, incidents, and mishaps as a loss of “situational awareness.” Mechanics and air traffic controllers also participated in these lively discussions. From these domain-developed discussions, SA soon became a construct worthy of scientific research, inasmuch that millions of dollars in grants have been expended for the study of SA. Although many in the aviation community may feel like they “own” SA, it has been overwhelming applied to other dynamic environments such as healthcare, process control industries, and surface transportation (Gugerty, 1997; Lau, Jamieson, & Skraaning, 2016; Stubbins, Chaboyer, & McMurray, 2012). The multi-domain application of SA has

several common denominators, but also contains many different applications such as ways to measure SA and how to train and teach SA.

Endsley (1995) created the most common cited definition of SA, which is a construct that operates on 3 levels: perception, understanding, and anticipation of future situations. Durso, Rawson, and Girotto (2007) offer a similar definition absent the hierarchical structure, which is defined as how one understands relevant information in a rapidly changing environment. SA is an important capability to have when operating in a dynamic environment. SA has been shown to be a distinct construct beyond other underlying mechanisms such as attention, memory, etc. (Durso, Bleckley, & Dattel, 2006). Good SA typically leads to better decision making, better understanding, and better performance (Endsley & Jones, 2012).

Class Design and Content

This first-time offered class for the graduate program drew a relatively large class roster. Enrolled students had a variety of aviation interests (e.g., pilots, management, education technology). During the first week of class, the instructor showed the film, *Premium Rush*, starring Joseph Gordon-Levitt. This action-packed drama follows the trials and tribulations of a New York City bicycle messenger for a day – quite a great way to start off a class! The film portrays the expedience of navigating a bicycle through a vastly changing dynamic environment by displaying the protagonist's processing of information to maintain a high level of SA. This movie quickly gave a good perspective of what SA is—now the challenge for the students was to understand the theory, apply the concept, and measure the construct. In another class period a guest lecturer, who has substantial experience in SA in industry and government, discussed real world experiences to the delight of the captured audience.

As is typical in a class seminar, much of the class period was devoted to discussing articles — in this case about 50%. Seminal, theoretical, and practical articles in SA were reviewed. In addition, articles about training, designing, and measuring SA were discussed. These articles included applications to aviation and non-aviation domains. Because of the students' varied backgrounds, topics could develop from an individual student's experience, leading to unexpected, but relevant discussions.

One of the first assignments for the class was to explain to a friend what SA was, and ask the friend to give examples of where he or she had witnessed good or bad SA. The student was then to report back to the class what the friend described. This exercise helped the classmate understand SA by articulating the definition, and then self evaluated their own way of describing SA in layman's terms.

Research Proposal

The most heavily weighted assignment was for to students to write a research proposal in regards to SA in aviation. For many students in the class, the research proposal was their first experience thinking and formulating ideas about research. Some of the proposals that students wrote for the class became the basis for their Master's thesis.

NTSB reports

Another assignment that received positive reviews required each student to present to the class findings an accident report from the National Transportation Safety Board (NTSB). Students made these presentation throughout the term. A requirement for the NTSB report was that the primary or secondary cause of the accident had to be attributed to poor SA. Additionally, the report had to be non-aviation related. It was obvious that each student presenter had thoroughly researched the report and delivered it well. However, it seems the most rewarding aspect were the comments and discussion that were generated in the class.

Class project.

Throughout the semester, the students worked on a class project. The requirements for the project was that an SA research study had to be conducted that involved human participants. The class had to design the research project, develop the stimuli, collect the data, analyze the data, and present the findings in a discussion and conclusion format. Approval from the Institutional Review Board (IRB) was required. Although it was required that the students conduct the study adhering to accepted research methods, the final reporting of the study was

allowed to be more lenient. Initially, the class project was to involve SA in aviation; however, the students decided to conduct the study in a non-aviation dynamic environment. In retrospect, conducting the study in a non-aviation environment may have been facilitated a better understanding and appreciation of SA in the aviation environment. The following sections describe the students design, findings, and applications of the SA project.

Student Design of the Research Project

Part of the class coursework included a group project, which was a research study designed and performed by the students. This research project not only helped to foster students' critical thinking skills, active learning, natural inquiry, but also gave students an appreciatiation and better understanding of conducting SA research. Several topics were considered for the research project, including observing and interviewing air traffic controllers at a local Tower/TRACON, and observing and videotaping racecar drivers practicing on a racetrack. However, it was determined by the students and the professor that pilots, air traffic controllers (ATC), and racecar drivers are professionally trained maintain good SA at all times. The class concluded it would be beneficial to measure SA of the general public in a non-aviation dynamic environment.

Why EPCOT? Situation awareness has been associated with the field of aviation for decades (Salas, Prince, Baker, & Shrestha (1995). To increase their understanding of SA in a public, dynamic environment, aviation students measured the SA of patrons and employees at Disney's EPCOT theme park. This environment was chosen for a variety of reasons:

1. The number of patrons and employees available to survey. EPCOT provided the students with a large sampling pool due to the large volume of park patrons and the large number of staff.
2. The park provided the students with a wide variety of patrons and employees to survey, although demographics were not considered as part of this survey. The diversity of participants assures the undistinguished data collection without any directive trends (e.g. the data is not correct if the participants are mainly consisting of middle age).
3. The abundant and realistic SA-related activities. Students studied three types of SA in EPCOT: spatial awareness, time awareness, and general awareness
4. Emergency situation potential. The public environment of the theme park allowed the students to question participants on potential emergency situations.
5. Good signage and visibility. EPCOT is filled with maps, signs, and other directional information. The researchers hypothesized that the visual cues at EPCOT would increase patron SA.
6. Hospitality. The atmosphere if Disney is famous for being open, friendly, and willing to host student researchers.
7. The location and transportation. EPCOT provided the students with an easily-accessible dynamic environment for study that was outside of the field of aviation.

Of these, the potential pool of participants in terms of size and diversity were the most important reasons for location determination.

Formulation of measurements

During one class lesson, the students collectively filled out an application form for Institutional Review Board (IRB) approval and prepared a plan for interviews. Students discussed SA measurement methods and questions to ask patrons and employees. Students formulated two groups of questions, separated for patrons and for park employees.

Students began preparations in the a few weeks leading up to the trip to EPCOT. The purpose of the study was to interview park patrons and employees. The students focused questions on patrons' awareness of their surroundings, theme park arrangement, and time awareness. Questions for patrons were mainly focused on their navigation skills (i.e., where the nearest exit was, where their car was parked, and where the nearest restroom was). Park employees were interviewed about their knowledge of safety measures in the event of an emergency. Questions for staff members were related to their actions in case of an emergency. Some questions for patrons and staff also were related to the awareness of current time, such as park closure time, or, for staff, time until their next break.

To measure SA, students recorded and later compared participant response time for each question. If applicable, some answers (e.g., "Where is the nearest restroom?") were checked for accuracy (Yes/No).

Results

Patrons

Fifty patrons participated in the study, and each of them answered 12 questions. The patrons' situation awareness was measured by analyzing confidence ratings and response times as opposed to the number of questions correctly answered by the patron. The questions correctly answered were used to identify valid data. For example, the response time that a participant took to point out the location on a map correctly was analyzed; conversely, if a participant did not point out the correct location, the response time was abandoned. There were seven yes-or-no questions. The descriptive statistics are summarized in Table 1.

Table 1. Responses to Specific Questions.

	N	Number of Yes	Percentage of Yes (%)
Meet-up Location	50	13	26.0
Point Location	11	11	100.0
Exit Direction	48	41	85.4
Park Front	48	42	87.5
Nearest Restroom	48	39	81.3
Point on Map	48	38	79.2
Drive to Park	43	24	55.8
Know Where Parked	24	21	87.5
Current Time	40	29	72.5
Park Close Time	47	28	59.6
Have Water	45	37	82.2

Note. Point Location = Point to the Direction of Meet-up Location, Point on Map = Point out Current Location on a Map

Confidence rating. Two of the 12 questions measured patron SA using confidence ratings. They were Car Location and Arrival Time. The scales of confidence ratings were from 1 to 5. One indicated the participant was not confident at all in their given answer, and 5 indicated the participant was very confident in their given answer.

Twenty-one participants of the 50 surveyed rated their confidence in their knowledge of Car Location. Of the 21 participants who rated their confidence, 18 participants, or 85.7%, indicated a 5 or very confident. The other three participants selected 3, or neutral/unsure.

For the question concerning Arrival Time, 48 participants of the 50 responded. The numbers of participants for each rating level are summarized in Table 2.

Table 2. Confidence Rating for Arrival Time.

Rating Scale	Number	Percentage (%)
1	0	0.0
2	1	2.1
3	5	10.4
4	17	35.4
5	25	52.1

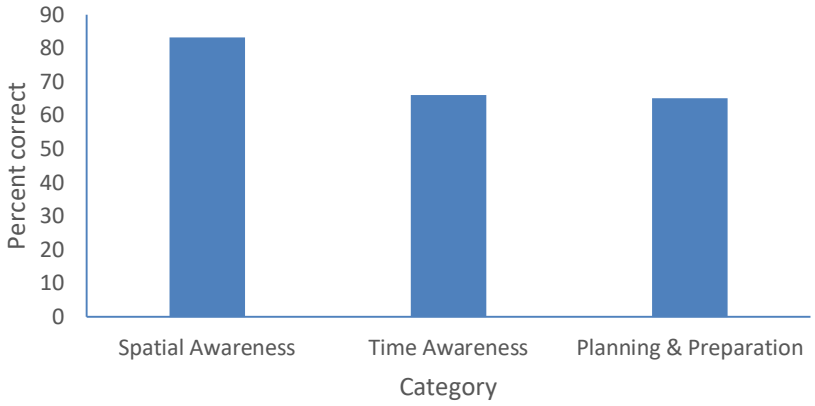
Employees

There were 15 theme park employees who participated in this portion of the study, and each of them answered six questions. The employee's SA was measured by analyzing response times to questions as opposed to the number of questions correctly answered.

Parallels to aviation

When analyzing the data, the yes-or-no questions from the survey were divided into three categories, including spatial awareness, time awareness, and planning and preparation. Spatial awareness consists of pointing to locations on a park map, direction to the closest exit, where the front of the park was, and the nearest restroom. Theme park patrons have to be aware of the spatial information so that they are able to enjoy the park by not getting lost, and to evacuate in a short time if necessary. Time awareness contains included questions about park closure time and current time. Time awareness is important because patrons need to plan the rest of their stay regarding current time and park closure time. Planning and preparation, which includes meet-up location, knowing where car was parked, and having fluids for hydration is another important factor. The results showed that the patrons' spatial awareness was much better than the time awareness and the planning and preparation. Good spatial awareness amount the partrons may be been due to repeat customers. However, repeat visits did not help them with the time awareness and planning and preparation. The mean percentage of yes for each category is shown in Figure 1.

Figure 1. Mean percentage of each category



The main purpose of the study was to measure SA in a dynamic environment in a field not related to aviation. A local entertainment park was chosen for the location of the study. Although on the surface the environments are dissimilar, parallels between a theme-park environment and aviation environment were evident and gave the aviation students the tools to understand and measure SA. Many of the questions asked of the park patrons can be related to aviation. For example, knowing how to immediately egress an airplane or airport terminal can be the matter of life or death. Other planning skills, such as a meet-up location in a busy amusement park is similar to having a contingency plan or alternative flight plan route.

An explanation of why some patrons did not have a meet-up location may be because people have become more reliant on cellphones and prefer to call members of the group in the event of separation rather than determine a meeting point in advance. However, relying on cell phones call in case of separation from party members is poor planning because cell phones batteries can die, or reception could be unavailable. This is in contrast to a pilot who loses communication because there is a defined protocol to follow in case such failure occurs.

Discussion

Because this 3 credit class was conducted during the summer, the semester was condensed to a 6 ½ week period. However, the variety of assignments, emphasis on theory, application, active learning, and teamwork seemed to be very successful. The course was quite comprehensive, but students seemed to enjoy putting in the work effort. Below are selected comments from the end of course evaluation.

- "Being able to conduct a survey for a class project was very helpful in understanding how research is conducted. The process of completing the IRB, developing the project questions, and working together to complete the project was a lot of fun and informative. The 10-minute presentations about non-aviation

related accidents was very useful and provided another way to interpret the levels of SA and apply them to non-aviation scenarios. At Embry-Riddle, we often focus on aviation everything, but this gave us a different understanding of the SA tool."

- "The detailed research papers allowed understanding in advance theories and concepts. The field work eased having experience on gathering data used to understand the construct of SA."
- "Group discussion and reading articles were an excellent source of knowledge. Overall, the class was very fun and made the time pass much faster than normal, in a good way."
- "…..the movie about SA is also a good example to learn the course content"
- "Examples of SA in real life and its applications in both aviation and other industries, e.g., medicine, driving, etc…… Also, accident reviews helped a lot. I liked the variety of readings (theoretical/empirical) that we went through during the course."
- "The course, I thought I would be an expert in because I am a pilot, and I thought I knew everything about Situation Awareness. Well, I was wrong, after the first class session I realized that I only knew the basics of SA. This course has given me a more thorough understanding of Situation Awareness and I can truly say this course has opened my eyes, it has changed the way I think about the situations while flying and I am confident that there has been an improvement in my personal Situation Awareness. This course was well involved, this course gave me exposure to experiments, this course opened my mind and perhaps changed my life."

Conclusion

There are three markers that appear to make this course design highly successful. The first marker is the end of semester evaluations. Student evaluation of the course across all questions was a 3.87 out of 4.0. However, it is the comments noted above that were most encouraging. The second marker is the reputation among students that the class was a positive learning experience as well was as an enjoyable experience. The third marker is that the maximum enrollment was reached soon after the course was offered for the second time. The instructor feels that this design of the class was highly successful, and looks forward to teaching it again.

References

Barkley, E. F. (2010). *Student Engagement Techniques: A Handbook for College Faculty*. San Francisco, CA: John Wiley & Sons.

Durso, F. T., Bleckley, M. K., & Dattel, A. R. (2006). Does situation awareness add to the predictive validity of cognitive tests? *Human Factors, 48*, 721-733.

Durso, F. T., Rawson, K. A., & Girotto, S. (2007).Comprehension and situation awareness. In F.T. Durso, R.S. Nickerson, S.T. Dumais, S. Lewandowsky, & T. J. Perfect (Eds.), *Handbook of applied cognition (2nd ed.),* (pp. 163-193). Hoboken, NJ: John Wiley & Sons.

Endsley, M.R. (1995). Towards a theory of situation awareness in dynamic environments, *Human Factors, 27*, 32-64.

Endsley, M. R., & Jones, D. G. (2012). *Designing for Situation Awareness: An Approach to User-Centered Design,* Boca Raton, FL: CRC Press.

Gugerty, L. J. (1997). Situation awareness during driving: Explicit and implicit knowledge in dynamic spatial memory, *Journal of Experimental Psychology: Applied, 3*, 42-66.

Lau, N., Jamieson, G. A., & Skraaning, G. (2016). Situation awareness acquired from monitoring process plants-The Process Overview concept and measure. *Ergonomics, 59*, 976-988.

Lee, V. S. (2004). *Teaching & Learning Through Inquiry: A guidebook for Institutions & Instructors*. Sterling, VA: Stylus Publishing.

Salas, E., Prince, C., Baker, D. P., & Shrestha, L. (1995). Situation awareness in team performance: Implications for measurement and training. *Human Factors, 37*, 123-136.

Stubbings, L., Chaboyer, W., & McMurray, A. (2012). Nurses' use of situation awareness in decision-making: An integrative review, *Journal of Advanced Nursing, 68*, 1443-1453.