ABLE FLIGHT AT PURDUE

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This paper discusses the human factors considerations associated with Able Flight at Purdue, a program that provides flight training to individuals with disabilities. The program requires a tailored approach to training due to the varied needs specific to each individual. Aircraft procedures and airfield operations are standard and all FAA regulations are followed, however, the way individuals with limited dexterity, limited hearing, or limited speech interact with the aviation system needs to be creatively approached with an open mind. The critical thinking used to address individual needs provides an excellent demonstration of problem solving that reflects human factors considerations, based on the SHELL model, reflecting the Software, Hardware, Environment and Liveware in the aviation system. Human factors considerations extend beyond flight preparation and flight, and encompass nontraditional methods of learning, in which flight instructors adapt traditional and standard techniques to provide effective and individualized training techniques. Training this unique population provides many benefits, including promoting diversity in the aviation industry and broadening the teaching skills of flight instructors.

Many developed nations have long recognized the benefits of social inclusion (The Charity Commission, 2001; United Nations, 2007; World Bank, 2013). The World Bank (2013) defines social inclusion as "both an outcome and a process of improving the terms on which people take part in society." Social inclusion is the opposite of social exclusion, and social exclusion can be a result of many factors, such as but not limited to age, sexuality, race, religion, mental illness, or physical disability. Social inclusion seeks to empower marginalized individuals or groups through integration of all societal members, with goals to improve peace, development, and human rights. Inclusion can have benefits that extend beyond the individual, fostering a culture of inclusion that may support a positive workplace culture, increased workplace satisfaction, and even increased innovation (Moon, Todd, Morton, & Ivey, 2012; Pearce & Randel, 2004).

There are many organizations and programs that exist with a mission to promote social inclusion. This paper describes one, Able Flight, including basic information and a discussion of the human factors components that are necessary to the program's success. Able Flight is a nonprofit organization that provides aviation related scholarships to individuals with a disability. Able Flight offers four scholarships:

- **Full Flight Training Scholarships** for people who wish to earn a Sport Pilot certificate,
- **Return to Flight Scholarships** for people who have become disabled after already having earned a pilot's certificate, and now wish to return to flying under the Sport Pilot Rule,
- **Flight Training Challenge Scholarships** for people who would benefit from dual instruction only, and have no current plans to seek a Sport Pilot certificate,
- **Career Training Scholarships** for people who wish to train to earn an FAA-issued Repairman Certificate (Light Sport Aircraft) with Maintenance Rating, or an FAA Dispatcher License, or to defray academic expenses while training for an aviation career (Able Flight, 2016b).

Able Flight has partnered with a number of organizations to deliver these scholarships. Purdue University is one of those partners, and fulfills the training for the Full Flight Training Scholarship. This partnership has benefited both Able Flight and Purdue.

Literature Review

Due to the technical nature of flight, Able Flight incorporates many aspects of Science, Technology, Engineering, and Mathematics (STEM) education. Broadening participation in STEM educational programs has been a goal of many programs, and the inclusion of underrepresented populations in STEM programs provides many benefits. The National Science Foundation has emphasized the importance on the development of a diverse STEM workforce in the United States (National Science Foundation, 2000, 2004). This same message was repeated by the National Science Board in 2010 through their report, Preparing the Next Generation of STEM Innovators (National Science Board, 2010).

A number of STEM oriented programs targeted to individuals with disabilities have been successful. The Experiential Learning for Veterans in Assistive Technology and Engineering (ELeVATE) program provides service members with vocational rehabilitation goals and results indicated that participants were more confident and had improved self-efficacy upon completion (Goldberg, Cooper, Milleville, Barry, & Schein, 2015). One major Midwestern university found that Student Learning Communities that provided knowledge, skills, and abilities curricula for students with disabilities were successful in engaging this unrepresented group to peruse STEM degrees (Izzo, Murray, Priest, & Mcarrell, 2011). Although there are numerous other examples, the Research Initiative for Science Excellence (RISE) program provides an excellent example of the potential benefits. RISE is a training program that seeks to further prepare and support minority students obtaining STEM degrees through research experience and mentorship (Schultz et al., 2011). Programs that target minority groups have the opportunity to positively impact underrepresented individuals by providing resources, education, and guidance that otherwise might not be available to them because of lack of inclusion. A secondary benefit of these programs comes through the direct interaction between more traditional students and minority groups, which results in a change in perceptions about the capabilities of people with a disability and their ability to positively influence society.

Able Flight at Purdue

The Able Flight program began a decade ago, and the first Full Flight Training Scholarship was awarded in 2007. For a short period of time, training was conducted at a variety of locations, including a personal hangar in Oshkosh, WI. In 2010, Able Flight partnered with Purdue University, which allowed the program to expand and provide a more robust training experience.

The Able Flight at Purdue program takes place every summer after Purdue University's spring semester and graduation ceremonies are over; the program typically starts in mid-May and finishes by early July. During this time, residential facilities are available and Able Flight participants live in one the university's newly constructed and fully accessible residence halls. Each participant has their own private bath connected to their room, which provides independence and privacy. Scholarship recipients also receive access to campus dining courts throughout their flight training. Since the basic needs of food and housing taken care of, Able Flight program participants can focus their time, energy, and attention on getting the most out of the Able Flight program.

Able Flight at Purdue requires a great deal of work and commitment on the part of the student. Many hours of studying and many hours in the plane are needed to become a confident, competent, and safe pilot. As recognized by Able Fight's mission statement, "individuals with a disability are presented with a unique way to challenge themselves through flight training, and by doing so, gain greater self-confidence and self-reliance" (Able Flight, 2016b). While an important goal for a Full Flight Training Scholarship recipient is an FAA Light Sport Pilot certificate, the program's impact is much greater than merely being a pathway to certification. The impact includes accomplishment and empowerment for participants, benefits associated with experiencing a fully inclusive environment for participants, and secondary benefits of broadening the perspective of participating CFI's, and positively influencing the culture of aviation through the association of Able Flight students with the larger aviation community. Able Flight at Purdue has realized a 100% completion rate, with 36 graduates as of 2016. It takes a dedicated team to ensure such a successful program, and it also requires application of human factors principals to modify traditional training methods to accommodate the unique characteristics of each Able Flight participant.

A Human Factors Approach to Able Flight

The most widely known framework for human factors in aviation may be the SHELL Model, which was developed in 1972 (Edwards, 1972) and subsequently endorsed by ICAO (International Civil Aviation Organization, 1989). The SHELL Model defines human factors in terms of the Software, Hardware, Environment and Liveware components, which work together, as centered around the Liveware (humans) as illustrated in Figure 1.

Figure 1. Diagram of SHELL components, with Liveware (human) in the center, surrounded by the Environment, and interacting with the Hardware and the Software and other Liveware (humans) (Hawkins, 1987).

In this case, the Able Flight program and its components are assessed from the perspective that the Able Flight student is the liveware in the center of the diagram. The CFI, Air Traffic Controller (ATC) and other pilots are the liveware at the bottom of the diagram. The hardware at the top of the diagram includes the aircraft, and adaptive physical aids that the pilot may use in training or flight. The software at the left of the diagram includes the rules, checklists and procedures, which are always based on traditional FAA flight protocols, but may include enhancements or modifications to reflect the need of the individual Able Flight student. The environment, at the right in Figure 1, includes the Able Flight system, including the natural environment as well as the social and economic factors.

The liveware considerations for Able Flight include the physical characteristics of the flight student, as well as the CFI. Since light sport aircraft are used, matching the size of the instructor to the size of the student may be important for weight and balance considerations, both to optimize aircraft performance and ensure that a reasonable fuel supply is available without exceeding the aircraft maximum weight limitations. Interaction with ATC is another liveware consideration, especially for deaf pilots. Deaf pilots rely on light gun signals when operating in a controlled airfield, and ensuring proper procedures and resources are available for both pilots and ATC are important. Purdue University upgraded their signal lamp to accommodate these operations.

Liveware considerations also reflect input characteristics, reflecting the way that pilots can receive information. This can affect the interaction between liveware and hardware. For example, it is appropriate for a deaf pilot to have a plane that allows the CFI to sit next to, rather than behind. The interaction between liveware and hardware also suggests that some aircraft may be better suited to some pilots, with examples as shown in Table 1.

Table 1.
Matching Able Flight Pilot Liveware with Aircraft Hardware to Ensure Compatibility

Aircraft	**Aircraft Characteristics**	**Pilot Characteristics**
Flight Design CTLS	Side by side pilot and co-pilot	Deaf or hearing impaired
	Longer cockpit	Tall pilot
Ercoupe 415C	Hand control for rudder	Pilot with limited use of legs
Sky Arrow L600	Finger brakes	Pilot with limited use of legs
	Ease of access to seat	Landing gear does not prevent wheelchair users from getting close

The general guidelines shown in Table 1 may be useful for conceptual discussion, however, it is important to note that individual characteristics and capabilities are more important than general guidelines, as evidenced by

Able Flight Pilot Jessica Cox, who demonstrates that a lack of arms does not restrict her from using the standard operating controls in the Ercoupe 415C, as shown in Figure 2.

Figure 2. Jessica Cox was born without arms and flies an Ercoupe 415C (Able Flight, 2016a).

Liveware considerations can also affect the interaction between the liveware and software, which includes the rules and procedures. For an Able Flight pilot in a wheelchair, the pre-flight checklist must be approached with a method to allow the pilot to instruct someone else to check the oil levels, rather than check the oil level themselves.

Liveware can affect the interaction between the liveware and the environment. In some cases, Able Flight pilots are more susceptible to heat due to the inability for individuals with a spinal cord injury to control their body temperature. To accommodate this consideration, training schedules reduced flights during the hottest part of the afternoon, and shifted training times to the early morning and evening when temperatures were lower. In addition to adapting to the environment, the Able Flight program results in changes to the environment, since the experience of Able Flight often changes the attitudes of CFIs and other aviation students and professionals who interact with Able Flight pilots. This change in attitude can foster a change in culture, which is one component of the environment.

Benefits

Problem solving and adaptive learning environments, which can be explained using the SHELL human factors approach, has facilitated the successful implementation and expansion of Able Flight at Purdue. This has resulted in documented success, both in terms of FAA certificates obtained, and the impact on the wider community. Able Flight participants have changed the attitudes of CFIs and other aviation professionals, and have contributed to a culture shift in the aviation community. Marketing and media for the Able Flight program has been extensive, with features on local television (Sullivan, 2015), in local newspapers (Flores, 2015; Higgins, 2015), on the internet, and even on national programs such as the Big Ten network (Tolley, 2016). This media attention fosters a broader impact, by changing how individuals and society perceive people with disabilities, their capabilities what they can accomplish, and how they can positively contribute to society.

The benefits to participants provide compelling evidence that the program impact and program success extends beyond successful completion of the program itself.

- Randy Green was born without hands or feet, but earned his Airline Transport Pilot (ATP) rating, the highest pilot certificate FAA recognizes. Randy received training through a Career Training Scholarship from Able Flight and is now flying professionally.

- Kevin Crombie received an Able Flight Full Flight Training Scholarship in 2011. After completing Able Flight at Purdue, Kevin enrolled in Purdue University's undergraduate aviation program. Since graduation, Kevin joined the aviation work force as an employee in the Commercial Space sector at the Federal Aviation Administration in 2015. Kevin purchased a Piper Cherokee 180 and continues to fly.
- Raymart Tinio is Deaf but dreamed to fly since he was a teenager. This dream became reality and was made possible through an Able Flight Full Flight Training Scholarship in 2015. Raymart is now an aviation graduate student at Purdue University; one of Raymart's goals is to improve communications between deaf pilots and air traffic controllers.
- John Robinson is a quadriplegic who received an Able Flight Full Flight Training Scholarship in 2015. After his successful completion of the program, he founded AV84all, a 501(c)(3) public charity with a mission to provide aviation for all and allow pilots with disabilities to fly (Robinson, 2016).
- Wesley Major was paralyzed in a motorcycle accident prior to participating in Able Flight. As a result of his positive experience in 2012, Wesley enrolled in the graduate program and is now a Ph.D. student at Purdue. Wesley's graduate research focuses on improving the airline transportation experience for disabled passengers. He has been a volunteer in the Able Flight program at Purdue since his Able Flight graduation, providing administrative support and serving as a mentor, as well as recruiting program participants, interviewing candidates, and providing media outreach.

Able Flight is a life changing program, and through the application of flight training, it allows individuals with a disability to expand their opportunities and challenge societal norms by demonstrating their ability to fly. During a luncheon among Able Flight staff, student pilots, and sponsors, Professor Bernard Wulle presented an important phase that changes how people think, "Employers should not see what people with disabilities can't do, but see what they can do" (Wulle, 2015).

Conclusion

The Purdue Able Flight program has been a dramatic success and has had a positive impact on both the participants, as well as the larger aviation community. The mainstream media generated by Able Flight at Purdue has provided an opportunity to positively impact the public's perception of people with disabilities, by focusing on their capabilities and abilities to positively contribute to society. The human factors associated with the Able Flight program are explained in the framework of the SHELL Model, which provides a context for the modifications and interaction between the Able Flight pilot as liveware, and the software, hardware and environment. Able Flight at Purdue is a successful program that can be duplicated elsewhere, using the human factors model explained in this article.

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