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Determining readiness for solo flight training: Towards defining the elements of competency

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Abstract

Flight instructors are responsible for deciding when student pilots make their first solo flights. Whilst these decisions are complex and challenging, little detailed guidance has been developed. This study aimed to articulate the elements of competence that experienced flight instructors focussed on and assessed, to make the decision to send student pilots on their first solo training flights. Participants were 30 Recreational Aviation Australia (RA AUS) senior and chief flying instructors. A qualitative design was used to explore participants' reflections on the elements of competency and behavioural markers they assess. The key themes identified from the thematic analyses fit well within the PAVE hazard checklist, which provides a framework for hazard awareness and management. The results of this study include a preliminary framework of specific competencies, which flight instructors can assess, as part of their decision making. Future research could lead to development of a checklist or scale that would further support flight instructors' decision making.

Key Words: Flight instructing, Solo flight training, Decision making, Safety in flight training, Assessment of competencies

A student pilot's first solo training flight marks an important milestone in their training and is a key component within the flight training syllabus (CASA, 2010). Solo flight training is thought to build student pilots' confidence in their developing airmanship capabilities. Improvements in consistency of aircraft handling and other key aspects of flight, such as situational awareness, tend to be noted following solo flight experience (Campbell, 1994; CASA, 2007). Flight instructors are responsible for making the ultimate decision to send a student pilot on their first and subsequent solo flights.

This decision can be challenging and complex, as it involves considering many different factors, including the student's demonstrated competence and confidence in flying the aeroplane and managing emergencies, as well as the weather conditions and separation from other traffic. A further challenge for flight instructors is in choosing the point in time at which to conduct the first solo flight exercise. The Civil Aviation Safety Authority (CASA) Flight Instructor Manual describes recognition or selection of the right moment to send a student pilot on a first solo flight as "one of the main problems of basic instruction…" (CASA, 2007, p.55). This is because the instructor has to balance competing demands when choosing the moment to conduct the exercise. On the one hand, the flight instructor balances their assessment of their student pilots' capability to fly safely and manage any emergency situations that might arise, which is generally based on relatively limited aeronautical experience. Whilst on the other hand, there is the expectation that the student will benefit from the solo experience and should not be held back from this until they achieve polished flight proficiency (CASA, 2007).

The CASA Flight Instructor Manual provides a brief and general guide for flight instructors towards their decision making. It includes points for instructors to consider in coming to their decision as to whether the student pilot has reached an acceptable standard for their first solo flight. Points raised include aspects of flying the circuit, as well as airmanship and management of emergencies. Whilst the points presented in this guide appear salient, there is relatively little detailed guidance to support flight instructors' decision making in this area. For example, there does not seem to be particular guidance on how to conduct the assessment of the student's readiness for solo flight training. The elements of competency, as well as relevant behavioural markers flight instructors should look for in their students' performance also do not appear to have been well articulated. Nevertheless, flight instructors who have the responsibility for sending student pilots on solo flights must have attained a level of experience and expertise (RA-Aus, 2014a). In the absence of more detailed guidance, this expertise informs their ability to make reliable judgements of student pilots' readiness to undertake solo flight training.

Expert knowledge and human decision making have received a large amount of research attention. A broad range of relevant theory has been developed that explains the natural methods of human decision making, including differences between expert

and novice decision makers (e.g. Glaser, 1999; Kahneman, 2011; Newell & Simon, 1972). Researchers in the area of the psychology of thinking and reasoning have advocated an heuristic-analytic, or *dual-process* theory of cognition and applied this in the area of judgement and decision making (Bonner & Newell, 2010; Evans, 2006). In summary, decisions can be made based on heuristic and/or analytic processes.

Heuristic reasoning relies on experience-based, trial and error learning, and is often based on intuitive sense developed from experience to find a "satisficing" solution. That is, a solution that aims for a satisfactory or adequate result, rather than the optimal solution. Analytic reasoning, on the other hand, utilises step-by-step procedures to quantify and model information to develop an optimal solution. Whilst limitations have been reported in the use of heuristic approaches to reasoning and decision making, particularly in novices, highly experienced experts appear very good at using this approach to judgement and decision making.

Clearly, there is great value in exploring and understanding experts' hard-won knowledge, both to support and foster novices' development and also to increase the proficiencies of experts themselves (Glaser 2009; Hoffman, Shadbolt, Burton, & Klein, 1995). The focus of the present study was to provide a first step towards articulation of best practice guidelines with the aim of supporting flight instructors' decision making. This work sought to explore the heuristic knowledge of expert flight instructors and articulate this in an analytic form.

As already mentioned, flight instructors balance the competing demands of the safety of their operation and the benefits of solo flight training to their students' development. As such, flight instructors are engaged in managing risk. A first step in risk management in this context, is an understanding of the key hazards which are known to lead to accidents in solo flight training operations. Following, is a summary of the relevant literature examining the frequency and types of accidents that have occurred in flight training and an introduction to a relevant risk management framework.

The frequency and types of accidents in flight training

Research has demonstrated that fewer accidents and fatalities occur in flight training than in many other types of general aviation operations (ATSB, 2014; NTSB, 2012). A recent statistical report shows that approximately 22% of General Aviation operations in Australia were defined as training operations in 2011 (BITRE, 2014, p.24), with an average number of hours flown each year between 2004 to 2012 in VH-registered flight training of 428 000 hours (ATSB, 2014). This report indicated the incidence of accidents and fatalities in flight training was approximately 40.61 accidents and 2.07 deaths in each million hours of flight, during those years. In contrast, operations categorised as Private/Business/Sport operations accounted for more 150

accidents and 20 fatalities per million hours and Recreational aeroplanes more than 180 accidents and 25 fatalities per million hours.

The ATSB Aviation Occurrence Statistics (2014) report identified some common themes amongst accidents and serious incidents in 2013 (2014, p.57). These included hard landings resulting in ground strikes, landing gear mechanical problems sometimes resulting in loss of control during landing, and aircraft coming too close to each other near Visual Flight Rules (VFR) reporting points and in the circuit area. Another theme identified was engine failures in single engine aircraft, resulting in successful forced landings. The themes raised in this report applied to training operations across all VH-registered aircraft. The limited research focussed on analyses of aircraft accidents involving student pilots on solo training flights and provides further details of areas of risk relevant to this type of operation.

Only one recent study was found that focussed on accidents involving student pilots engaged in solo flight training operations (Uitdewilligen & de Voogt, 2009). This study examined the circumstances of 390 aircraft accidents occurring between 2001 and 2005. The analyses were based on National Transport and Safety Bureau (NTSB) probable cause reports. Due to the sampling procedures and the nature of these analyses, it is acknowledged the results can only represent a cross section of incidents in one place and time. A key finding was that a high proportion of accidents (64%) occurred in the landing phase. This large number of accidents in the landing phase generally concurs with other sources focussed on flight training and other aviation operations (e.g. Baker, Lamb, Li, & Dodd, 1996; Olson & Austin, 2006; Rantz, Olson, & Dickinson, 2001). Approximately 45% of accidents occurred on the final approach or landing and 19% occurring during the landing roll. There is a body of literature which has examined landing accidents and has established these as the most prevalent causes of nonfatal accidents (e.g. Benbassat & Abramson, 2002; Benbassat, Williams, & Abramson, 2005; Olson & Austin, 2006). Uitdewilligen and deVoogt (2009) identified a further six percent of accidents occurred during the go around or aborted landing, another six percent occurred during taxiing and further five percent occurred during the take-off.

Overall, Uitdewilligen and deVoogt (2009) concluded most accidents involving student pilots undertaking solo flight training occurred due to pilot error (93%) and most were classified as skill based errors (e.g. failure to maintain directional control, inadequate compensation for wind). Only ten percent were related to decision/planning errors (e.g. inappropriate in-flight planning and improper decision making, and just four percent were caused by system errors (e.g. diminished brake functioning). Although generalisation of these results to future flight training is limited, the findings of this accident-based research point to the many specific hazards involved in solo flight training. This is useful information because the safety of aviation operations can be actively managed. This commences with an awareness of hazards relevant to the operation.

The pilots' hazard checklist

Key priorities for flight instructors include the safety of the operations for which they are responsible and management of risk to within reasonable limits. The Federal Aviation Administration (FAA) FlightAviation Instructor's Handbook describes risk management as "a logical process of weighing the potential costs of risk against the possible benefits of allowing those risks to stand uncontrolled." (2008, p. 9-2). In the course of their work, flight instructors are continually engaged in processes where they identify hazards, or sources of danger, assess the degree of risk and determine the best course of action.

A first and critical step in this process is the perception of hazards. A relevant checklist aimed at orienting pilots to key domains of aviation operation is presented and discussed in the FAA Aviation Instructors' Handbook (2008, pp 9-6 to 9-8). The PAVE checklist describes four key domains in which hazards frequently occur. In summary, these include:

P – *Pilot in Command*

This domain includes consideration of aspects of the adequacy of the pilot's experience, including proficiency, currency, recency, as well as the pilot's physical and emotional condition.

A – *Aircraft*

This domain includes aspects of the aircraft's adequacy for the flight, including familiarity with the aircraft, airworthiness and equipment such as a lighting, instrumentation and radios, performance in the current conditions, and fuel sufficiency for the planned flight.

V – *EnVironment*

This domain includes aspects of the flight environment such as weather, terrain and obstacles, as well as the airport and airspace. Considerations include ceiling, visibility, wind direction and strength, icing risk, as well as procedural requirements relevant to the runway and airspace in use.

E – *External Pressures*

This domain includes externally applied pressures or expectations with regard to completion of a flight, despite the presence of significant hazards. These pressures can be applied by anyone associated with the flight. For example, the pilot, a colleague or supervisor, a student pilot or passengers may have expectations about completing a flight and may not fully understand the nature of the hazards present on the day.

The PAVE checklist provides an easy-to-remember method for orienting pilots and flight instructors to key domains in which aviation hazards frequently present. The PAVE checklist can easily be applied to identify key hazards as part of the process of a flight instructor's decision to send a student pilot on a first solo flight. For example, *Pilot in Command* may involve aspects of proficiency of the student pilot. *Aircraft* may include the relevant aspects related to the airworthiness status of the aircraft as well as the student pilot's capabilities to manage any emergency situations. *EnVironment* may include consideration of weather and traffic density during the intended flight, and the student pilot's ability to effectively manage these. *External Pressures* may involve identifying and managing expectations held by the student pilot or others about engaging in solo flight training within a defined timeframe.

To date, there has been no consensus on any particular best practice assessment procedure for making the decision to send a student pilot on a solo training flight. The number of accidents still occurring during solo flight training seems to warrant efforts to develop further supports for flight instructors' decision making. Articulation of the student pilot's capabilities in flying the aircraft and in managing key hazards related to solo flight training operations seems an important initial step. The present study aimed to collate and analyse the reflections of the elements of student competence that experienced flight instructors focussed on and assessed to make the decision to send student pilots on their first solo training flights.

Method

Semi-structured interviews were used to explore the research question. The approach was phenomenological in that it aimed to elucidate the views and experience of participants. The method involved a systematic approach to transcript analysis and reflexive attention to the way the data was produced and interpreted (Smith & Osborn, 2008; Willig, 2013).

Participants

Purposive sampling was used to select participants from around Australia, who we knew to be experienced flight instructors, engaged in teaching student pilots within Recreational Aviation Australia (RA AUS). Of the 30 participants who provided responses, 27 (90%) were male. The mean age of respondents was 58.92 years (SD=9.47 years), with the youngest participant being 42 years and the oldest 75 years. Participants' mean years of experience providing flight training ranged from three to 29 years (Mean = 11.73 years, Median = 8.50 years). Seventeen (57%) held Chief Flying Instructor roles in RAAUS flying schools. Although all participants were qualified RAAUS flight instructors, two held Airline Transport Pilot Licences and another 12 held Commercial Pilots Licences. Eight participants (27%) held current CASA Flight

instructor ratings. The mean of participants' total hours of aeronautical experience was 7 185 hours, with experience ranging from 512 hours to 20 816 hours, and median of 4 600 hours.

Procedure

Approval for this project was obtained from the relevant University human research ethics committee. Individual interviews were arranged as part of a larger project examining experienced flight instructors' reflections on a broad range of relevant learning and teaching issues. Participating flight instructors received a research information sheet and provided written consent to participate.

Interviews were conducted in person and began with an introduction to the research and a question along the following lines, "How do you know when it is time to send a student pilot on their first solo flight?" Active listening skills were used to elaborate participants' views and experiences. All interviews were audio recorded and converted to a typed transcript for analysis, as further described below.

Data analysis

Using thematic analysis, we identified coherences in the data that were grounded in the reflective accounts of the participants (e.g. Braun & Clarke, 2006; Smith & Osborn, 2008). We acknowledge it is axiomatic that these qualitative findings were co-produced, initially through our interview discussions and later through our interpretation of transcript content.

The analysis began with reading the interview transcripts and initial identification of themes from participants' reflections and discussion. These themes were then transcribed into separate tables along with verbatim copies of participants' quotes. Some overall themes were observed to emerge from this data, which we describe next.

Results

We identified some overall themes from flight instructors' responses. These included (a) the centrality of safety in flight instructor's decision making, and (b) elements of competence. Following is a description of the identified themes and selection of evidence from flight instructor's interview data.

(a) The centrality of safety in flight instructor's decision making

It was most evident in the responses from all participants that they each made the safety of their flight training operations a central priority. As such, the decision to send a student pilot on a first solo flight was founded on ensuring the student would be

able to complete the flight safely. Some examples of comments made by flight instructors included:

> *We always err on the side of safety. No one goes solo here until they are ready. (I13)*
>
> *I am looking to see they are safe, [that they can] recognise if there is something going wrong [and that] they can fix it appropriately. (I9)*
>
> *…can they fly the aeroplane safely? (I17)*
>
> *You have to make sure they are totally safe. (I18)*

In gathering information to inform their decision about the readiness of student pilots to undertake solo flight training, flight instructors reported they were actively assessing student pilot's capabilities to fly the aircraft safely. They reported they evaluated their students' capabilities, to assist them to manage the various hazards relevant to solo flying.

(b) Elements of competence

The results of the thematic analysis identified the criteria or elements of competence that flight instructors reported they assessed, in order to determine student pilots' readiness for solo flying. Given the central nature of safety in flight instructors' decision making, these results are presented within the PAVE hazard checklist.

- ***PAVE hazard checklist - Pilot in Command***

The participants in this study discussed their approach to ab-initio flight training and the largest quantity of discussion in our interviews was on the topic of assessing student pilots' competence. It is important to note that solo flight training occurs within a syllabus of ab-initio flight training (CASA, 2007, 2010; RA-Aus, 2014b). In summary, student pilots learn the fundamentals of preparing for flight, piloting the aircraft in all stages of flight, emergency management and circuit training. The latter includes take-off, climbing, cruising, approach and landing, as well as radio procedures and rules of the air.

Many flight instructors indicated that in making their decision to send a student pilot on a solo flight, they were looking for a range of competencies in relation to flying the aircraft around the circuit, as well as personal or psychological aspects, such as confidence and independence in decision making during normal procedures as well as simulated emergencies. For example:

> *It's not that they can do a couple of landings unassisted. [It's]…that they can do the whole package. (I10)*

> *…we are looking for the procedures, the body language and they can fix things, listening for traffic. You build up a whole picture [of the student pilot's capabilities and readiness for solo flying]. [I28]*

The participants reported further specific elements that they focussed their assessments on. These emerged as key themes during analyses of interview transcripts. These themes included the need to see independence and consistency in flying the elements of the whole circuit, including landings to a safe standard, an ability to recognise and independently manage deviations in flight path and ability to safely perform an aborted landing, or "go-around".

1. ***Independence and consistency in flying the whole circuit***

The criteria that the participants indicated they assessed included consistent safe flying of the elements of the whole circuit. Comments related to the student pilots' independence in flying the aircraft included:

> *… I find that as they get near solo, my talking decreases to zero. When you compare that to the initial training, you are just talking all the time. (I28)*

> *When I sit there and do absolutely nothing. You can tell when they are getting close when you don't have to put your hand on anything or say anything. (I13)*

> *They have mastered the physical skill of flying the aircraft and we don't have to do anything for a period of time…We are basically baggage and sit on your hands. (I17)*

> *Some instructors will say that if they get into the plane and the student does three perfect circuits in a row, they will send them solo. I am a little more conservative. I want to see more consistency than three. If I am assessing them, I should be able to sit there and say and do nothing. If I have to give them any prompting, they are not ready. (I9)*

Comments related to the student pilots' consistency in flying the aircraft included:

> *Consistency is important (I8). I do worry about consistency (I2).*

> *Some instructors say if you have done three unassisted circuits and landings, then you are ready for solo. But you really have to sit with someone for an hour of solid circuits and you'll find that at three quarters of the way through, the wheels will start to fall off. But you really need that consistency to solo. You can get out too early. If I could be accused of anything it is getting out too late because I need to be convinced… (I15)*

> *…consistent flare, consistent hold off… (I29)*

The process I use is I look for consistency. They do a minimum of three circuits, and I want to see the numbers the same on every circuit. (I23)

Within this theme of independence and consistency, many participants discussed some further specific criteria they looked for in student pilots when they assess their readiness for solo flying, including landing the aircraft to a good standard, ability to recognise and manage deviations from the desired flight path on approach to landing, and competence in managing aborted landings, or "go-arounds".

1a Landing the aircraft to a safe standard

The indicators are, of course, that they are able to produce a series of unassisted landings. (I21)

They must be able to land the aircraft… (I4)

…when you can fly a circuit with your mouth closed and they [student pilot] do the landing as well, you know you are getting very close [to solo standard]. (I22)

1b Ability to recognise and independently manage deviations in flight path

The biggest thing I think is when the student can identify when things don't look right. (I29)

As they get near solo, we wait as long as possible when a problem is developing to see how and if they handle it. If I have to take over, or if it isn't corrected, then the student is not ready for the first solo. (I3)

I don't look for perfect circuits. If they have a problem, recognize it and fix it, that is ok. I am not looking for perfection. I am looking to see they are safe, recognize if there is something going wrong, they fix it appropriately. So they are demonstrating that they are taking command and recognizing problems emerging. (I9)

The obvious one was when the student did the whole circuit perfect every time, you think well this guy is ready, but that can be a terrible mistake, if he misses some things. So you make sure you induce some problems for them to fix. (I8)

I like to see them muck one up really badly and get a high bounce or a really bad undershoot, or a wind gust that has mucked up that particular landing and I like to see them be able to cope with that. That will tell you they are able to handle something bad that happens to them. (I14)

In summary, flight instructors indicated that they assessed student pilots' abilities to independently land the aircraft to a safe standard and to recognise and correct

any significant deviations in the desired flight path, as part of the criteria for determining readiness for solo flying. However, there are occasions when hazards present because deviations in the approach path and parameters such as speed and height may exceed limits which cannot be safely corrected, or the runway is obstructed. A vital strategy for managing these hazards is to perform an aborted landing or go-around.

1c Safe flying of go-arounds and willingness to go-around

Many participants discussed the need for students to identify when a go-around was necessary and initiate these appropriately, as well as demonstrate consistent, safe go-around procedures.

> *You have to teach the go-around technique and the willingness to go-around. You have to get the idea out of their head that going around equals failure. The more experienced you are, the more likely you are to go around if you need to. (I8)*

> *They don't have to be perfect landings. I don't look for perfect landings. [The required standard isthat]… they recognise that everything [approach parameters] is going pear shaped and have the common sense to go around. (I26)*

> *[We] do lots of go-arounds and make sure they can identify when things go wrong. (I29)*

2. Student pilot is relaxed, appropriately confident and taking command

In addition to the technical capabilities already described, many flight instructors identified aspects of the personal functioning of the student pilot as important indicators of readiness to undertake solo flight training. These included being relaxed, appropriately confident and also taking command in flying the aircraft and managing other aspects of the flight, such as radio calls. "Taking command" included a sense of taking responsibility, making decisions and proactively managing all aspects of flying the aircraft, to ensure the successful conclusion of the flight. Examples of flight instructors' comments included:

> *I can see the confidence [in the student pilot] right from pre-flight. His mannerisms, the way he acts in the aircraft, a sense of professionalism without me having to have input. He takes command and I am sitting there as if I am a sack of potatoes. He does it all without any input [from the flight instructor] at all. (I4)*

My personal one is when he trims the aeroplane correctly. Trim right and relaxed and letting the aeroplane do the work. …I personally look at the last bit of the final [approach] when they are trimmed and relaxed. (I11)

…There's the body language of the person…when they are relaxed… (I28)

Sometimes it is not obvious that they are in command, as long as they are reacting correctly, they don't always exude confidence. (I7)

Overall, there was significant agreement between flight instructors that student pilots must be able to consistently and independently fly the whole circuit. Key indicators of readiness were in landings being to a safe standard, that the student pilot was observed to be managing any deviations from the desired flight path, and safely initiating and managing aborted landings. Other indicators of readiness included observations the student was relaxed, confident and taking command of flying the aircraft. These themes each reveal elements of competence flight instructors assessed within the Pilot section of the PAVE checklist. The next category of the PAVE hazard checklist is focussed on the Aircraft.

- ***PAVE hazard checklist - Aircraft***

The participants discussed their responsibilities for managing hazards related to the aircraft, including ensuring it was airworthy, had sufficient fuel for the flight and that pre-flight checks were completed prior to the student pilot undertaking initial solo training flights. They also discussed the elements they assessed regarding the student pilot's proficiency in managing problems which may develop with the aircraft, whilst engaged in solo flight training.

Proficiency in managing potential Aircraft-related problems

Many participants provided outlines of the criteria related to the student pilot's proficiency in managing circuit emergencies, including flap and engine failures. For example:

…we have to cover all contingencies, like engine failure on take-off and engine failure on downwind, flap failure…before we send them on their first solo. (I3)

Always before [solo flying] we have done some emergencies in the circuit. They have to know what to do if…they have an engine failure on take-off or any other part of the circuit, because it has to become a reflex and automatic. (I22)

Before solo they have to have done an engine failure after take-off [EFATO training] and are under the pump to do the things that will keep them safe. Have a plan and can execute the plan without panic and change of mind. And can formulate a plan in an instant. (I12)

We introduce engine failures on the runway, at 50 feet, a bit higher, 700 feet crosswind. That is part of two lessons on circuit emergencies before solo. We run them through a flapless and glide approach. (I11)

There was significant agreement between flight instructors that student pilots must be able to consistently and safely apply emergency procedures as part of hazard management. The student pilot's capabilities in managing these emergencies were seen to be an important part of the assessment they conducted towards a decision to send a student pilot on a first solo flight.

- ***PAVE hazard checklist - EnVironment***

The participants recognised and discussed the ways they manage hazards related to student pilots on solo flights which were specifically related to the environment. These included weather and consistency of weather conditions, sufficient daylight to complete the flight, situational awareness and management of separation from other aircraft, and management of radio calls.

1. Weather and consistency of weather conditions

The participants explained their consideration of hazards involving the weather and wind conditions in particular. Some instructors indicated they preferred to send student pilots on first solo flights in calm conditions, whilst others felt it was not so much the conditions that were important, but whether the student pilot was handling the conditions adequately and that these conditions would remain consistent for the duration of a solo flight. For example:

…I am also fussy about conditions. I worry about sending people up when the conditions aren't perfect. I would prefer sending people on a still morning. (I2)

…the weather has to be near perfect and the wind light. (I3)

The weather, changing conditions, if you are expecting the wind to do a reversal, those sorts of things are also considerations before sending a student solo. (I7)

The weather doesn't matter, it depends on the student and if they can deal with the weather on the day. If it is windy and gusty, but the student is handling it ok and I can get around 3 circuits without doing or saying anything, it's a pretty good indication they know what is going on. It's all about being safe. (I25)

Having decided that they can go solo, it depends on the conditions. If we are blessed with good conditions it is easier. Some students have been overcooked and well and truly ready, but the weather has been so bad I won't send them up. I had one student 6 months ago, went solo in not-ideal weather conditions and he absolutely blitzed it… (I20)

2. Situational awareness and management of separation from other aircraft

Situational awareness is a term used to describe the pilot's knowledge of what is going on around them, ability to predict events based on this knowledge and taking appropriate action. This includes, for example, a pilot being aware of the current location and future position of other aircraft and using this information to position their own aircraft to avoid flying too close to other aircraft. As with consideration of weather conditions, there were differing views amongst flight instructors about whether to choose moments for first solo flying when there was minimal traffic for the student pilot to contend with, or to assess their ability to manage separation in busier airspace as part of the overall assessment of their readiness to undertake solo flight training.

Situational awareness is a critical thing, initial circuits is a lot to take in. (I20)

If there are a whole bunch of people in the circuit, that is not good because they [the student pilot] don't necessarily have the situational awareness to deal with that. (I25)

…the circuit [has to be] quiet. I wouldn't send a student solo in a busy circuit… The circuit has to be quiet… (I3)

I also take into account the amount of traffic in the circuit or the amount of traffic expected in. You wouldn't send a student solo when the flying doctor was 10 miles out. (I7)

Traffic can come up, but usually they are already proficient with handling traffic [before going solo]. (I12)

If they can't handle traffic, if that student can't place themselves in the circuit with traffic they shouldn't be up there alone. (I10)

I load them up. Lots of traffic, I say "Who is in the circuit and where are they? Fly 60 knots behind that aircraft." (I29)

On a closely related point, flight instructors also discussed assessing student pilots as having a basic competence with radio procedures. Separation via radio alerted see-and-avoid and air traffic control depends on this capability. Whilst flight instructors mentioned that radio work was not a main priority, in that it is prioritised last in the popular taxonomy "Aviate, Navigate, Communicate", it was still mentioned as a factor in the decision. For example:

I am not too worried if they do much else besides fly the aircraft… (I21)

Usually in the session before [final assessment for a first solo flight]… I give them a fairly heavy workout with radio and procedures. I simulate incoming aircraft. The solo is usually less pressure than the lesson before. (I23)

3. Sufficient daylight

There was also consideration of sufficient daylight for the intended flight plus an additional safe margin, for example:

> *…and not towards the end of daylight. I wouldn't send a student solo with only twenty minutes of light left… (I3)*

The three themes identified from flight instructors' responses within the Environment section of the PAVE checklist showed some differences in approach. Some flight instructors insisted on calm weather conditions without the challenge of other traffic, whilst others only indicated they actively trained and assessed students' capabilities in relation to the conditions on the day. Overall, the results of these analyses identified the elements of competence flight instructors assessed within this category section of the PAVE hazard checklist. The final category of the PAVE hazard checklist is focussed on external pressures.

- ***PAVE hazard checklist - External pressures***

The participants reported situations they had encountered where they felt some pressure from student pilots and others. This pressure was in relation to meeting others' expectations. Examples where flight instructors noted student pilots applied pressure upon them were in instances where they wanted to fly, and wanted the flight instructor to ignore some significant hazards, or did not want to fly due to under-confidence. In this example, a student pilot had travelled a long way to complete flight training that day, but was not fit to fly.

> *I had a… student who turned up, had been partying until late, presented with a migraine. I told them… "I am not teaching you today. You are not fit to fly." That's one of the first things we do, make sure we are fit to fly. I sent them home and they were really livid. "I've come all the way over here…"(I16)*

This example shows how the flight instructor has the opportunity to manage the expectations of those students (or others), who might apply pressure to fly when it is not safe to do so. Many of the participants in this study spoke about their experiences of assessing and actively managing expectations of more over-confident and under-confident students. In both examples, flight instructors sought to engage the student pilot in self-assessment processes to help determine readiness for solo flight. Examples of managing overconfident student pilots' expectations included:

> *…the overconfident student wants to get up by himself, when he is not ready to. (I7)*

> *Some of the students are really gung-ho and want to solo and you have to reign a bit of that in. Give them an engine failure on take-off and that seems to sort them out. (I13)*

Conversely, another frequently discussed problem that flight instructors raised was student pilot's under-confidence in their abilities and resulting reluctance to fly solo. Again, flight instructors actively managed this by involving the student in self-assessment of their capabilities. For example:

> *…I ask them, "Are you happy to do one circuit on your own?" Some will say "I'd like to do a couple more [circuits] with you…" And I say "Ok", and we do it. [I say], "[I]…won't help with anything." [Then] I ask them, "How do you feel?" And if they say "Yep.", then I know it's time. (I26)*

> *I say to them, "You have to feel confident because you will be in the aircraft on your own. Can you do that?" I get the student involved in the assessment process. (I10)*

In summary, these examples point to the need for flight instructors to both be aware of, and to seek to manage external pressures to try to ensure safety of the operations for which they are responsible. These pressures appeared to be part of the dynamic situation flight instructors engage with when making their decisions to send student pilots on solo training flights.

Overall, these analyses highlighted the centrality of safety in flight instructors' decision making in sending a student pilot on their first solo training flight. The themes identified from flight instructors' responses within the current study were shown to fit with the PAVE hazard checklist. The analysis of these expert flight instructors' responses identified the elements of competence that they assess in making their decision about whether their student pilots are ready to undertake their first solo flights.

Discussion

The aim of the current study was to collate and analyse the reflections of the elements of student competence that experienced flight instructors focussed on and assessed to make the decision to send student pilots on their first solo training flights. Whilst flight instructors regularly make these decisions, very little formal guidance is available pointing to the elements of an effective assessment. The present study was the first that we know of to utilise a qualitative methodology to examine responses from a sample of experienced flight instructors, who were asked what they assess to determine their student pilots' readiness for solo flight training.

In summary, the results of the thematic analyses showed the flight instructors in the present study placed the safety of their students and flight training operations as their central priority. As such, a major theme identified in this study was that flight instructors sought to assess their students' readiness for solo flight training in direct relation to the hazards of solo flying that they identified. Many of the initial comments flight instructors made when addressing the interview questions included that they were assessing their student pilot's capabilities to consistently and independently fly the aircraft safely. As the discussions progressed, flight instructors spoke about the need to also ensure the student pilot could manage emergencies that might occur in relation to failures on the aircraft and that they were handling the weather conditions, particularly wind, on the day.

The focus on safety and hazard identification that flight instructors spoke about prompted use of the PAVE checklist, as a framework within which to present the collation of the key elements flight instructors reported they assessed. This checklist was published in the FAA Aviation Instructors Handbook (FAA, 2008), as a framework for pilots to assist them to perceive and manage hazards. The results of this study fitted neatly with the four categories of risk within the PAVE checklist. In addition to the elements of student competence, several other relevant responsibilities were identified. A summary of the results, including elements of student pilot competence in relation to readiness for solo flight training is shown in Table 1.

Insert Table 1 about here

Table 1 shows a summary of the elements of competence the participants reported they assess in appraising the readiness of student pilots' prior to solo flight training. The results of the present study showed flight instructors routinely and comprehensively assess student pilots' competence across the key elements of flight, which have been shown to be the causes of accidents in flight training. With most accidents occurring in solo training attributed to pilot error (Uitdewilligen & de Voogt, 2009), it seems essential that flight instructors assess student pilot's competence to fly the whole circuit with consistency. Almost two thirds of accidents occurring in solo flight training and more broadly in flight training and in general aviation operations have been shown to occur in the landing phase (e.g. Benbassat & Abramson, 2002; Benbassat, et al., 2005; Uitdewilligen & de Voogt, 2009). Again, the results of the current study showed flight instructors focussed their assessments on the student pilot's independence and consistency in landing to a safe standard. There are interesting opportunities within the learning and teaching literature to develop students' capabilities to reflect and engage in self-appraisal of their performance in this area (e.g. Olson & Austin, 2006). Although shown to be less frequently related to training accidents, the present study showed there was also an emphasis on assessing the student pilot's capabilities to execute aborted landings/go-arounds and to manage various circuit emergencies.

There was some variation seen in the approaches flight instructors used to manage hazards related to the PAVE - EnVironment category. Flight instructors in the present study reported that they either opted for calm conditions, or trained and assessed their students as capable of managing safely in the weather conditions on the day they flew solo. A further issue identified was that of either trying to ensure solo flights occurred when the traffic level was low in the circuit area, or that the student was trained and assessed as competent in managing separation from other aircraft. This involved elements of situational awareness, being able to use strategies to ensure separation from other aircraft, such as extending a leg of the circuit or slowing down, and basic competence with radio work. In each instance, flight instructors reported they were actively engaged in managing these hazards. In addition, flight instructors identified various PAVE - External Pressures exerted by student pilots and others upon their decision. It seems likely there would be many other examples of pressures which flight instructors would need to be aware of and manage. Future research may be warranted to further explore this area.

The process commenced in the present study is a first step towards articulation of important knowledge held by expert flight instructors. This sought to understand and articulate the elements of competence experienced flight instructors assess in making their decisions about student pilots' readiness for solo flight training. We recognised that experienced flight instructors held heuristic knowledge that informed their decision making and sought to present this within an analytical framework (Bonner & Newell, 2010; Glasser, 2009; Kahneman, 2011). As such, the results of the current study may be a first step towards understanding the elements flight instructors used to assess student pilots' readiness to undertake solo flight training.

The current study utilised a qualitative design to explore the experience and perceptions of a selected sample of 30 experienced flight instructors. As such, the results may be seen as a reflection of the opinions of this participant group and may not represent the practices of the broader community of flight instructors. Therefore, further research in a more representative sample of flight instructors is needed to develop greater confidence in the validity of these results. One approach to this could include a broad survey of flight instructors, asking for their appraisal and input to develop the list of elements of student pilot competence developed in the present study. Further research in this area could ultimately lead towards development of formal assessment criteria, a checklist or measurement scales, which could perhaps become a useful, best-practice guide for supporting flight instructors' decision making.

In conclusion, the present study set out to take a first step towards understanding the elements that flight instructors consider in making their decision about the readiness of student pilots to undertake their first solo training flight. To date, there has been little formal guidance for flight instructors engaged in making these decisions and research shows that whilst flight training is generally safer than other general aviation operations,

many accidents have occurred. The results of the present study showed flight instructors regarded safety as central to their operations and presented a collation of the elements of student pilot competence, as well as other responsibilities reported by flight instructors. These were each discussed as strategies flight instructors used to actively manage the perceived hazards of solo flight training. The elements of competence were seen to be consistent with the results of findings in the limited literature examining accidents in solo flight training and flight training more broadly. Future research could focus on validating the results of this exploratory study and could lead to a checklist or measurement scale that provides a best practice guide for flight instructors responsible for the decision to send student pilots on solo training flights.

Table 1

Summary of elements of student pilot competence and flight instructors' other responsibilities

PAVE category	Elements of student pilot competence to be assessed	Flight instructor's other responsibilities
Pilot in Command	**1. Independence and consistency in flying the whole circuit, including:** 1a. Landings are to a safe standard. 1b. Recognise and independently manage deviations from desired flight path and other parameters (e.g. speed, height). 1c. Safe go-arounds and willingness to go-around. **2. Student is relaxed, confident and taking command.**	
Aircraft	**1. Proficiency in managing circuit emergencies, including:** 1a. Engine failure after take-off. 1b. Engine failure in the circuit. 1c. Flapless approach and landing.	**Preparation for flight, including:** • Airworthiness of the aircraft. • Fuel is sufficient for the flight. • Pre-flight checks completed.
EnVironment	**1. Managing current weather conditions.** **2. Management of separation from other aircraft, including:** 2a. Situational awareness. 2b. Management of separation from other aircraft. 2c. Radio work to a good standard.	**1. Check weather conditions will remain consistent, including wind.** **2. Sufficient daylight.**
External Pressures	Some examples include student pilots': • Fitness to fly (I'M SAFE). • Over-confidence. • Under-confidence.	**Flight instructors can be intentionally aware of any other pressures others may apply in relation to their decisions.**

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