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Experiential learning and the classification of team skills in pilot education

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ABSTRACT: In this article, the author discusses a research project being undertaken by the AERO Lab that uses Crew-Centred Flight Training (CCFT) coupled with a database of behavioural markers in scenario-based Line Oriented Flight Training (LOFT) simulator sessions. The classification of team skills, using this behavioural marker database, will be developed using Artificial Intelligence (AI) classification techniques. It is hypothesised that the use of these AI classification techniques will improve the ability to distinguish between pilots with a healthy repertoire of team skills for use on the flight deck and those pilots who have a lesser repertoire of team skills. In this way, CCFT techniques can be modified to improve a student's learning of team skills. Given that it is generally accepted that the majority of aircraft accidents are caused by pilot error and that these errors are caused substantially by a breakdown in team processes, it would suggest that the experiential learning of team skills should improve error management and reduce aircraft accidents. This is especially so since situated cognition in LOFT simulator sessions makes this form of experiential learning particularly powerful.

INTRODUCTION

There is general consensus that pilot error is the major factor in aircraft accidents. There is also consensus that this error is more likely to be the result of poor team skills rather than poor technical flight skills. Flight crews have demonstrated poor team skills in the following general areas:

- Situational awareness;
- Interpersonal communication;
- Workload management and task delegation;
- Leadership;
- Decision making;
- Resource management;
- The process of building and maintaining an effective team relationship on the flight deck.

In an effort to reduce the incidence of these human factor-related events, NASA sponsored a workshop to discuss *Resource Management on the Flight Deck* in San Francisco, USA in 1979 [1]. As a consequence of this Workshop, Cockpit Resource Management (CRM) training was developed and introduced by numerous airlines represented at this workshop. Since then, there has been an evolution of CRM to include larger groups or teams. As a result, CRM has become known as Crew Resource Management to reflect the importance of crew members associated with the flight who are not members of the flight crew. The evolution of CRM training in commercial aviation is discussed by Helmreich, Merritt and Wilhelm [2].

In this article, the author briefly describes the development of CRM and outlines a methodology for embedding this in-flight training at the ab initio level through Crew Centred Flight Training (CCFT) [3]. The author also outlines a project that uses experiential learning in scenario-based flight instruction simulator sessions, termed Line Oriented Flight Training (LOFT). These scenario-based LOFT sessions will utilise a database of behavioural markers that are classified using Artificial Intelligence (AI) techniques.

THE EVOLUTION OF CRM

Helmreich et al have suggested that CRM has undergone five developmental stages from 1979 [2]. The first stage was an outcome from the *Resource Management on the Flight Deck* Workshop sponsored by NASA in 1979 [1]. The CRM training that was introduced was a version of the training used by corporations to increase managerial effectiveness and was based on the *Managerial Grid* developed by Blake and Mouton [4]. The CRM training centred around pilots determining their own managerial style and examining strategies to correct deficiencies in these styles, such as lack of assertiveness on the part of first officers and authoritarian behaviour on the part of captains. LOFT sessions were also introduced as part of the training. In these sessions, flight crews could practice the CRM techniques learnt in the classroom setting.

The second stage began around 1986 when NASA held another workshop [5]. At this workshop, the aviation industry met to discuss the current status of CRM training. It was apparent that the focus of CRM had changed in emphasis from management styles to group dynamics with a corresponding change of name from Cockpit Resource Management to Crew Resource Management. The new courses became more team-oriented and focused more on flight operations [6]. CRM concentrated on briefing strategies, team building, decision making, situation awareness and stress management [2].

The third stage began in the early 1990s when CRM training began to become specialised in areas such as human factors, aspects of the aviation system, organisational culture and flight-deck automation. At the same time, CRM training began to broaden to include other groups of personnel like flight

attendants, maintenance personnel and dispatchers. Helmreich et al point out that although these modified courses of CRM filled a particular niche need as they became more specialised and accentuated the crew element of the training, they did have a tendency to diminish the focus on the primary goal: that of reducing the human error associated with air travel [2].

The fourth stage began around the mid-1990s when the Federal Aviation Administration (FAA) introduced a major change in the qualifications and training of airline flight crews [7]. The Advanced Qualification Program (AQP) is a voluntary programme that allows US airlines to develop their own specific programme to fit their needs. The FAA requirement is that the airline must integrate CRM training into the flight training and provide both CRM and LOFT training for all of their flight crews. The majority of US airlines now have AQP. Crews now undergo full flight scenarios in the simulator and are formally evaluated during these simulator sessions (Line Oriented Evaluation – LOE).

Helmreich et al argue that while the integration of CRM training into technical airline flight training (through the various AQPs) has improved the quality of flight crew training, there are some issues that still need to be addressed [2]. These issues include some flight crew members not responding well to some aspects of CRM training and the problem that flight crews may revert back to *type* after a long time interval from the last CRM session. There is the tendency that an over-regulation of CRM principles through the use of airline-specific Standard Operating Procedures (SOPs) may in fact lead to flight crews *going through the motions* rather than internalising the implied crew attitude and behaviour. Further, the research indicates that CRM and AQP training had become very culturally specific and could not be efficiently and effectively transferred from one airline to another. This was especially the case when programmes were transferred from the USA to another country [8].

As a consequence Helmreich et al argue that the fifth stage of CRM development has returned to the original proposition of reducing the level of human error [2]. CRM has become focused on error management.

The author agrees that error management is the overarching axiom for improving aviation safety. However, the author argues that if CRM training, including error management, were introduced in an integrated manner at the very beginning of flight training rather than at the advanced level, crew-beneficial attitudes and behaviours would become well entrenched. This would alleviate some of the CRM training problems currently encountered in airline flight crews [3][9-11].

CREW-CENTRED FLIGHT TRAINING

Flight training is conducted in the very small space of the cockpit of a small light aircraft. This leads to a very close, almost intimate, educational experience for both the student and instructor. Because of this and the *one-on-one* learning experience, the student is exposed to an educational environment that is relatively unique. This form of experiential learning is very powerful in terms of learning outcomes.

As a consequence, traditional pedagogical approaches to flight instruction have achieved a high level of technical flight proficiency and have, therefore, remained relatively unchanged and unchallenged since the early days of flight instruction. The way instructors instruct has changed very little since the early *Tiger Moth days* of the Royal Air Force.

Given the multi-crew environment in modern airline operations, it is no longer sufficient for an individual to be just technically competent; it is also necessary for an individual to have learnt team skills, and acquired an ability to assess and manage errors in a way that improves overall flight safety.

As stated above, airline CRM training has addressed this. However, there is still the assumption that improvements in crew processes will come about naturally if crew members become familiar with their style of crew behaviour, and understand that there may be a need for improved communication and coordination. It should not be assumed that members of the crew possess team skills and that somehow they are innate or have been learned during ab initio flight training or elsewhere.

CRM courses that explore the relationship between individual behaviours within the crew and their associated crew outcomes may yield an understanding of group processes and team effectiveness. However, they will do relatively little to help flight crews reproduce favourable behaviours when placed in emergency flight situations. When a person is in a highly aroused condition, he/she tends to revert back to well-learnt behaviours, exhibiting whatever response is most dominant for that person in that particular situation [12]. In order for pilots to incorporate desirable team behaviours into their behavioural repertoire, or to extinguish undesirable team behaviours, they must be learnt in real team situations (by way of experiential learning) and reinforced with positive feedback from the team. The use of Line Oriented Flight Training (LOFT) sessions has proved to be a useful tool in this learning process [13].

Crew-Centred Flight Training (CCFT), devised by the author, develops a methodology that incorporates Crew Resource Management (CRM) and error management as an integral component of the educational process rather than part of the academic course content [3]. That is, a student learns CRM and error management through experiential learning sessions in the simulator and aircraft rather than by classroom teaching.

By developing a CCFT (or andragogical) approach at the more technical ab initio flight training level, an environment is created which reinforces behaviours and attitudes that are deemed to be most beneficial in group or team environments. Because these behaviours and attitudes have been learned at an early stage in a pilot's cognitive and psycho-motor development, they are likely to resist decay and are, therefore, more likely to be manifested at times of high arousal in emergency situations later on in a pilot's career.

> *The aim of Crew-Centred Flight Training (CCFT) is to provide a nurturing environment in which a pilot can learn to be safe and proficient in the technical aspects of flying, and more importantly, learn the educational and team processes, embodied in the training, which will provide a foundation for further development* [3].

The central principle of CCFT is the establishment of a student-instructor team or crew that focuses on this aim and takes responsibility for the student's learning. Traditionally, ab initio flight training has been mediated using an instructor-

centred approach with the instructor focusing on the aim and taking responsibility for the student's progress. As a consequence, few students have adequately learned the educational and team processes embodied in the flight training.

The CCFT methodology will be used in scenario-based simulator sessions.

EXPERIENTIAL LEARNING: SCENARIO-BASED SIMULATOR SESSIONS

The simulator, or flight training device, will be used to conduct LOFT or full-flight missions. These will be identical to the full flight lesson that the student would normally undertake in a real aircraft. The simulator will also be used for the evaluation of the flight lesson (LOE). The simulator will be used instead of the real aircraft because of the following reasons:

- Flight training is more cost effective on the simulator because it is cheaper and safer to operate than a real aircraft;
- Flight training is more educationally effective on the simulator because the flight lesson can be stopped, reviewed and repeated.

All flight lessons will be simulated in the simulator. These include both the basic general handling exercises, which on average last between one and one and a half hours, and the navigation exercises, which last on average three and a half hours. All aspect of the flight will be simulated and, to all extents and purposes, will be identical to the real flight lesson on an aircraft. The student-instructor crew will be evaluated on their performance as a crew. Additionally, the instructor will be evaluated on their ability to deliver the flight lesson using CCFT methodology, and the extent to which they embrace and deliver the content from a crew-centred perspective. The evaluation (Line Oriented CCFT Evaluation – LOCE) of the student-instructor crew will be performed by AERO Lab trained evaluators and use a list of the behavioural markers described below.

A preliminary investigation of the education transfer from the simulator to the aircraft indicated that students who had undertaken experiential learning on the simulator prior to the aircraft generally performed better than average [14].

BEHAVIOURAL MARKERS

Behavioural markers have been utilised as a tool to evaluate flight crew performance since the mid-1990s [15]. This is essential if CRM concepts and practices are to be assessed, reinforced and used to develop further training and education requirements. The set of behavioural markers developed by Helmreich, Butler, Taggart and Wilhelm results from the evaluation of a set of observable behaviours on the flight deck using the Line/LOS checklist [15]. These behavioural markers are also closely related to the attitudes measured by a revision of the cockpit management attitude questionnaire, the Flight Management Attitudes Questionnaire (FMAQ) [16].

The behavioural markers in the Line/LOS Checklist has been modified by the author to suit the flight deck or cockpit of the flight training environment and derive naturally from the CCFT methodology described by the author in ref. [3]. Examples of these behavioural markers are as follows:

- An environment for free and open discussion is established and maintained;
- Flight briefings are technically and operationally complete. They address crew coordination. Flight tasks are clearly defined including planning for abnormal situations, ie engine failure on take-off and after take-off. Missed approach procedure is also tackled;
- Crew atmosphere is task- and operationally-specific, ie crew interact socially during times of low workload (team building) and are focused on tasks during high workload periods;
- Both the student and instructor ask questions to clarify actions and decisions made by each other, and directions and clearances from air traffic control;
- Crew members feel comfortable to express their concerns about the operation of the flight, ie they speak up and persist until they are comfortable with the situation;
- Operational decisions of the flight crew are expressed clearly and acknowledged by the other crew member. Both the student and instructor seem to have the same understanding of the situation.

There are 25 behavioural markers for use in the LOCE. Negative (0) or positive (1) outcomes of the behavioural markers are reduced to an overall score for the student-instructor crew. The 25-dimensional vector derived from the crew in the simulator will be used as an input vector to an intelligent agent. The output vector will be generated from the behavioural marker set observed in the real aircraft.

INTELLIGENT AGENT CLASSIFICATION TECHNIQUES

As outlined above, the full mission scenario-based simulator sessions will be conducted using CCFT and evaluated using a set of 25 behavioural markers (LOCE). The project will explore various Artificial Intelligence (AI) classification techniques to improve the classification of student learning of team skills and technical flight skills. The AI classification techniques under investigation are discussed below.

The author has investigated a form of a self-organising map, namely topographical mapping to see if this will aid in the classification of teams skills in student pilots [17]. Other forms of topographical mapping have been considered involving harmonic averages [17]. The author has shown that this provides a good mapping of the input data and could be useful as a classification tool.

The project will explore another type of mapping: the fuzzy cognitive map [18]. Fuzzy cognitive maps are a software emulation of the way that an expert thinks and classifies the data set. They mimic human reasoning and decision making.

The project will also explore the use of support vector machine software, which performs a mapping from the input data set onto a feature space which provides a separating hyper-plane between classification sets within the data, thus classifying the data [19].

SUMMARY

Simulator sessions will be conducted that simulate the whole flight lesson. These lessons will include basic flight skills training and advanced navigation training. The student-instructor crew will perform the flight lessons exactly as they would be performed in the aircraft. This form of experiential

learning is considered to be very powerful in terms of the effectiveness of the teaching and learning.

CCFT methodology will be used to aid in the student's learning of team-beneficial behaviours and attitudes. These are considered important in the multi-crew environment on a flight deck. In order to evaluate the effectiveness of CCFT, an evaluation tool, LOCE, has been developed that comprises a set of behavioural markers which have been shown to correlate to crew behaviours and attitudes that have sound CRM concepts. AI classification techniques will be investigated to develop a tool that can be used by non-experts to evaluate the learning of team skills.

This project is in its infancy and it is hoped that the acquisition of a three-axis, full motion simulator by the AERO Lab will greatly assist in the development of this project and the learning of team skills at an early stage in a pilot's education.

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