Air Crash Investigators - comments on a pedagogical strategy to increase intrinsic motivation in order to enhance student learning.

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***Abstract**: Aircraft Systems for Aviators is an undergraduate course undertaken by prospective pilots in a School of Engineering and Information Technology. Usually, the course content of this type of course is mostly factual-type information. The present study introduced a teaching strategy loosely based on the television program* Air Crash Investigators *as a source of intrinsic motivation. Learning outcomes, as measured by exam results, were compared to a control group who did not experience the study of air accidents and incidents associated with aircraft systems. Results show that the use of air accidents and incident scenarios had a positive effect on learning outcomes. The rationale employed to justify this claim is discussed with recommendations for further investigation into the effects of arousal versus performance in a learning environment.*

Introduction

In their work on learning theories and the application of these theories to aviation education, Bye and Henley (2003) maintain that as well as an understanding of the use of knowledge and the acquisition of complex psychomotor skills, there is also a need to be cognisant of the rôle of goals, motivation and affect (emotions, values, feelings) in the learning process. This paper will comment on a teaching strategy that aims to increase student intrinsic motivation and affect in a degree program that caters for prospective Royal Australian Air Force (RAAF) and Royal Australian Navy (RAN) pilots.

The program is the Bachelor of Technology (Aviation) degree [BTech(Av)]. This Engineers Australia accredited degree is designed to provide a tertiary level of education to prospective Australian Defence Force (ADF) pilots at the Australian Defence Force Academy, (Harrap, Burdekin and Lewis, 2007).

The University College at the Australian Defence Force Academy (ADFA) is a College of the University of New South Wales (UNSW) and has provided undergraduate and postgraduate degree programs for the Australian Defence Force (ADF) since ADFA's commencement in 1986. Since the inception of the BTech(Av) degree program in 2001, the degree has evolved from an engineering program with human factors awareness and safety management systems courses to a more aviation-oriented program with a greater emphasis on safety management systems and behavioural and cognitive science courses, (Lewis and Harrap, 2009).

One course that has maintained its status as a core course of the BTech(Av) program is Aircraft Systems for Aviators. The course attempts to provide the student with generic information pertaining to such subjects as aircraft hydraulic systems, aircraft electrical systems and such like – in essence, knowledge associated with the various sub-systems that generally are found in most types of aeroplanes. Similar courses are a component of several Australian University aviation degree programs as well as being a major component of the Civil Aviation Safety Authority (CASA) Air Transport Pilot Licence syllabi of aeronautical knowledge training, (CASA, 2002). This paper will describe some of the strategies employed to enhance student learning outcomes and increase the intrinsic motivation of the aviation students especially with reference to the Aircraft Systems for Aviators course.

The content of most aircraft systems-type courses deals with mostly factual-type information; referred to by Biggs (1999a) as lower-order-type information. The lecturer for this course brought to the position some thirty years of military and airline experience as a pilot where the transition from one aircraft type to another involved several weeks of face-to-face classroom lessons pertaining to aircraft systems. The lecturer for this course was therefore aware of the nature of the information – factual, lower order information devoid of critical thinking and analysis. The critical thinking and analysis had been carried out by the aircraft designers and aeronautical engineers prior to any pilot ground-school training process. However, the lecturer for this course aimed to try and present aircraft systems in such a manner as to promote critical thinking and analysis as well to satisfy the University and Engineers Australia graduate attributes. The aim was to elevate the learning outcomes of Aircraft Systems for Aviators to include the "ability to undertake problem identification, formulation and solution", (Engineers Australia, 2006, p3) as well as to develop in the students "the skills involved in scholarly enquiry" (UNSW Academic Board, 2003).

One strategy that was employed to achieve the above aims was to have the learner make a class presentation to his or her peers relating to an aircraft system sub-system that had failed and caused an accident or incident. The student would be assigned an aircraft system to be the subject of her or his enquiry. Using the model of the television program *Air Crash Investigator*, where the accident or incident was precipitated by a failure, malfunction or incorrect procedure, the student would then perform research and from that initial research select the particular accident or incident that was to be the subject of their presentation. In their investigation into "what went wrong" with the particular aircraft sub-system the student would be required to search the literature, compare opinions and findings from various authoritative sources and present a scenario on the consequences of the failure, malfunction or pilot/operator error. The student would then compare any recommendations or ameliorating consequences that may be offered as a contribution to a future safety management system. It was hoped that this strategy would foster in the students a level of critical thinking as well improve communication skills in an area of technology that was germane to their future rôles as pilots and managers of aircraft systems. Student presentations [PowerPoint and notes] were placed in an on-line teaching forum and students were advised that content relating to the particular aircraft system was examinable material. Approximately 25% of total face-to-face teaching time was devoted to the *Air Crash Investigator* teaching strategy.

The mark that would be awarded to the student for the display of his or her acquired knowledge and more importantly, for the depth and breadth of her or his research and critical analyses, would be the extrinsic reward for the assessment item. The hypothesis is that by setting the learning exercise in the context of "a smoking hole in the ground" or an excellent piece of airmanship, the presentation of a disaster or near disaster tapped into an arousal effect which increased the intrinsic value of the learning exercise, especially for a cohort of prospective pilots. According to Rigby, Deci, Patrick and Ryan, (1992), intrinsically motivated behaviours are performed out of interest and thus require no reward other than the spontaneous experience of interest and accompanying enjoyment.

It would appear to be somewhat ironic that there is a need to increase motivation, either intrinsic or extrinsic, for prospective pilots. The pre-requisite for selection as a pilot is a demonstrated high degree of motivation (Defence Force Recruiting, 2006). As well as the high motivation and persistence required to acquire technical skills there is a large expense involved in flying training. In order for the Australian Defence Force to invest public resources in a candidate pilot – he or she must have demonstrated to numerous selection boards and panels a strong desire to fly. However, the need to maintain or increase student motivation for prospective pilots at the Academy lies in the fact that, while the academic component of the degree is carried out by the University of New South Wales at the Australian Defence Force Academy in Canberra, the flying training is carried out much later by BAE Systems personnel in Tamworth, NSW and then even later, by Royal Australian Air Force personnel at Pearce, WA. Young pilot candidates, keen to fly, must 'endure' some three years of academia before stepping into the cockpit of an aeroplane. This separation of academic pursuits and the flying training component of this BTech(Av) degree program is in marked contrast to the other Australian Universities that integrate the flying training program with the academic program, (Lewis and Harrap, 2008).

It might be considered to be drawing a long bow to claim an association between arousal, intrinsic motivation and learning outcomes. However, this paper will describe a controlled experiment where for one cohort of students the accident investigation scenario was not employed. The learning outcomes of this cohort will be compared to the learning outcomes of a cohort of students that 'enjoyed' the arousal experience. In this manner it will be demonstrated that the teaching innovation may have had a significant effect on student learning outcomes.

The difficulty of evaluating any teaching innovation or teaching strategy cannot be over stated. Gibbs, (1992) reports that exam results and conventional student feedback is unlikely to support the case for introducing a teaching innovation. However, this paper will use a statistical analysis to compare two sets of students' exam results; one with the teaching strategy and one set without. The analysis will demonstrate that exam results for Aircraft Systems for Aviators showed a significant improvement when an intrinsic motivational teaching strategy, based on a scenario similar to the television program *Air Crash Investigator*, was used. A partial correlation of the students' exam results from two different years, controlling for their weighted average mean scores for all courses taken in the same semester, will demonstrate that it is valid to compare the exam results of two different cohorts of students as a measure of success or otherwise of a teaching strategy.

In order to provide some explanation of the rationale behind using *Air Crash Investigation* – type learning material into an aircraft systems course, this paper will also provide a brief explanation of the neuro-psychological process where arousal enhances the processing of long-term memory.

Air Crash Investigation as an intrinsic motivator

As a pilot/lecturer on a university campus, colleagues and acquaintances often make enquiries relating to the cause of the most recent air crash or air incident. Cobb and Primo (2003) maintain that aircraft accidents and incidents fall under the rubric of disaster news – news that tends to dominate the media until the lack of new information precludes further coverage. Interest is categorized into information on victims, damage, cause and cure, (Cobb and Primo, 2003). Another indicator of the interest generated by aircraft accidents and incidents is the relatively high ratings of such television programs such as *Air Crash Investigations*. *Air Crash Investigation(s)* is the Australian and UK title of the program. It is also known as *Mayday* in Canada and *Air Emergency* in the USA. It is a program that documents the events that lead up to an air crash or a near accident; it deals with the aircraft systems and human-factor failures and shortcomings. Episodes feature re-enactments, interviews, testimony, computer-generated imagery and sometimes the actual cockpit voice recordings. As well as being described as an exceptional TV show, its popularity is indicated by the number of re-runs or repeats on free-to-air television as well as pay television channels, (Cobb and Primo, 2003).

If university colleagues and acquaintances are fascinated by aircraft accidents and incidents, then the interest displayed by practicing pilots verges on the obsessive. This interest can be partially explained by the 'it could happen to me', syndrome, (Hawkins, 1987). Australian aviation authorities and transport authorities of many overseas countries publish air safety magazines and journals to educate and inform the pilot population. Air accident investigation authorities are not necessarily interested in ascribing blame for a particular air accident or incident but they have as part of their mandate a mission to comprehend the causes of air accidents and incidents with the goal of preventing a re-occurrence, (ICAO, 2001). Journals, bulletins and articles that describe air accidents and incidents inform the pilot regarding issues pertaining to his or her own safety as well as the safety of his or her aircraft, crew, passengers and cargo. The preoccupation with self-preservation (both from a physical well-being perspective as well as preservation of professional reputation), may explain the level of arousal experienced by most aircraft crews when reviewing aircraft incidents and accidents, (Hawkins, 1987).

Biggs and Telfer (1987) document the affect of arousal on the process of learning. As well as an energising effect of arousal, Biggs and Telfer (1987) point out that too much arousal can have an interfering effect on performance and the learning process – refer to figure 1. The usual process of learning involves selecting, processing, storing and recalling information. Biggs and Telfer (1987) maintain that an arousal system produces an orientating response which aids the processing of long-term memory inputs. The Yerkes-Dodson Law, (the inverted U-shaped curve of arousal versus quality of performance diagrammatically represented in figure 1) states, in part, that simple tasks are performed better under high degrees of motivation or arousal, (Biggs and Telfer, 1987).

A physiological explanation of this phenomenon is offered by Buchanan and Lovallo (2001) whose experiments supported the notion that elevated corticosteroids (produced during arousal) produced an enhancement of memory in humans. It must be noted that, in the present study, within a classroom setting, the arousal effect was such that the students were not aroused to the point on the Yerkes-Dodson curve where the effect of too much arousal had an interfering or deleterious effect on performance.

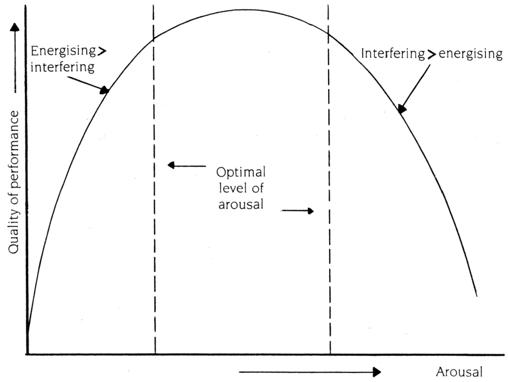

Figure 1: General relation between arousal and quality of performance (the inverted U)

Source: Biggs & Telfer, (1987, p.63).

As previously mentioned, Gibbs (1992) expounds the difficulty of finding a metric to support or not support any learning innovation. Hewson (2005) has advised that the issue of 'difference' is a problem. This can be solved by splitting the student group (which may disadvantage one half). In the study under review, this experimental design problem was solved by delivering the course one year using the arousal/intrinsic motivator of descriptions of air accidents. In a subsequent year the lower-order factual information was delivered without the learning exercises and student presentations associated with aircraft accidents and incidents – substituting a multi-choice type class test for the individual student presentation. The workload and reorganisation required during a program change process provided academic staff with the rationale to justify what might be perceived as a disadvantage to this student cohort.

Results

The mean of the exam results of 22 students who 'enjoyed' the intrinsic motivational effect of aircraft accidents and incidents was calculated. Also, the mean of the weighted average means for all courses undertaken by each of the 22 students in the same semester was calculated. Similarly, the mean of the exam results of the control group of 30 students [not motivated by aircraft accidents and incidents] and the mean of the weighted average mean of all courses undertaken by these students in the same semester was calculated. These means with standard deviations are presented in table 1.

Table 1: Means with standard deviations of Aircraft Systems for Aviators exam results and weighted average means [in same semester] of intrinsically motivated students and control cohort.

Student Cohort with intrinsic motivational effect		Student Cohort without intrinsic motivational effect	
Mean of Exam Result	Mean of Semester Weighted Average	Mean of Exam Result	Mean of Semester Weighted Average
76.2 [Std Dev. 5.5]	72.1 [Std Dev. 5.0]	65.1 [Std Dev. 9.2]	67.4 [Std Dev. 7.7]
n = 22	n = 22	n = 30	n = 30

Results showed that mean exam score for the students who had experienced the intrinsic motivational effect was 76.2 (sd = 5.5), while for the students who had not experienced the intrinsic motivational effect the mean exam score was 65.1 (sd = 9.2). A t test on the difference between means was statistically significant [t (50) = 5.0, $p<.05$]. However, a comparison of means of exam scores does not necessarily support the notion that a teaching innovation has a positive effect on learning outcomes, especially when comparing two distinct cohorts of participants (Gibbs, 1992).

A comparison of the exam results of the two cohorts of students – one with the learning exercises associated with aircraft accidents and one without – indicates that the exam results of the students who experienced the intrinsic motivational effect scored better than their semester weighted averages for all courses. On the other hand, the exam results of the students who did not experience the intrinsic motivational effect scored worse than their semester weighted averages for all courses.

The validity of being able to make a comparison between the two student cohorts lies in the effect of the correlation between a student's individual Aircraft Systems for Aviators exam result and his or her weighted average mean for all courses for that semester. A Pearson correlation between individual exam scores for Aircraft Systems for Aviators and individual weighted average mean scores for the student group that did not experience the intrinsic motivational effect produced a correlation of $r = .74$; this correlation was significant at $\alpha = .01$ [$r(28) = .74$, $p<.01$]. A Pearson correlation between individual exam scores for Aircraft Systems for Aviators and individual weighted average mean scores for the student group that did experience the intrinsic motivational effect produced a correlation of $r = .70$; this correlation was significant at $\alpha = .01$ [$r(20) = .70$, $p<.01$]. In order words, there is a high correlation between an individual's exam score for Aircraft Systems for Aviators and his or her overall academic ability.

Having established the validity of the relationship between exam score in a particular course and a student's overall academic ability, the result described in table 1 becomes meaningful upon examination of the partial correlation between student exam scores and their student group whilst controlling for the individual weighted average mean scores of the semester under review. In this manner it is conjectured that some control is applied to account for differences in student groups due to cohort interactions; morale of the particular student group; environmental factors etc. While it is conceded that the application of the individual weighted average mean scores of the semester under review as a controlling factor is not an absolute measure, such an application goes some way in overcoming the objections of Gibbs, (1992) who reported that exam results are unlikely to support the case for introducing a teaching innovation.

In the present study, a partial correlation between student exam scores and their student group whilst controlling for the student's weighted average mean scores (achieved in the semester under review), produced a correlation of $r = .53$; this correlation was significant at $\alpha = .01$ [$r(49) = .53$, $p<.01$].

Discussion

According to Howe (2008) it is not sufficient to merely claim a difference in result means even if that difference can claim degrees of significance but rather to explain a difference in terms of 'effect size' and make a meaningful interpretation. In table 1 it can be seen that the difference in exam scores between the teaching innovation and the control group is 11.1 marks improvement in overall test and exam results, or 4.1 exam score marks *above* the weighted average mean compared to 2.3 exam marks *below* the weighted average mean when the teaching innovation was not employed.

It would seem that there may be an energising or intrinsically motivating effect produced with the incorporation of *Air Crash Investigator* – type scenarios into an aircraft systems course. Whether this effect translates into a positive learning outcome – measured by exam results, can only be claimed if one assumes that exam results are an accurate and reliable tool for measuring whether the student 'has learnt more'.

This paper has not mentioned the student feedback received from University administered teaching and course evaluations nor has this paper explored the literature regarding the merits or otherwise of class presentation assessment. However, it is worth reporting that higher ratings of satisfaction with the course and teaching method were achieved when the *Air Crash Investigator* teaching paradigm was employed. Also, from a subjective classroom experience perspective, students seem to be more engaged in the subject matter and perhaps may be considered to have adopted the characteristics of the 'deep learner' as reported by Marton and Säljö (1976 cited in Biggs 1999b).

Conclusion

Notwithstanding the rationale employed in the statistical analysis or perhaps because of it, an improvement in learning outcomes is claimed for a pedagogical strategy to increase intrinsic motivation if one can count exam results to be a measure of learning outcomes. This strategy relies on the energising and intrinsically rewarding effect produced when candidate pilots study aircraft systems from the perspective of the popular television series – *Air Crash Investigators*.

References

Biggs, J. (1999a). *Teaching for quality learning.* Buckingham: Open University Press.

Biggs, J. (1999b). What the student does: teaching for enhanced learning. *Higher Education Research and Development, 18*(1), 57-75.

Biggs, J. & Telfer, R. (1987). *The process of learning (2nd ed.)*. Sydney: Prentice-Hall.

Buchanan, T., & Lovallo, W. (2001). Enhanced memory for emotional material following stress-level cortisol treatment in humans. *Psychoneuroendocrinology 26*, 307-317.

Bye, J. & Henley, I. (2003). Learning theories and their application to aviation education. In, I. Henley (Ed.), *Aviation education and training* (pp 3-29). Aldershot: Ashgate Publishing Company.

Civil Aviation Safety Authority. (2002). Air Transport Pilot Licence: Syllabi of Aeronautical Knowledge Training. Accessed at: http://www.casa.gov.au/scripts on 15 Jun 2009.

Cobb, R. & Primo, D. (2003). *The plane truth: airline crashes, the media, and transportation policy*. Washington: Brookings Institution Press.

Defence Force Recruiting. (2006). Pilot Selection Procedure: Canberra: [DFR-RECPRO058]

Engineers Australia. (2006). Engineers Australia policy on accreditation of professional engineering programs [Document No. P02] Canberra: Engineers Australia.

Gibbs, G. (1992). *Improving the quality of student learning.* Oxford: Oxford Centre for Professional Development.

Harrap, M., Burdekin, S., & Lewis, R. (2007). The development of the bachelor of technology in aviation degree program at the Australian Defence Force Academy. In H. Sondergaard & R. Hadgraft (Eds.), *Proceedings of the 2007 Australian Association for Engineering Education Conference*. Melbourne: AaeE.

Hawkins, F. (1987). *Human factors in flight*. Aldershot: Gower Technical Press.

Hewson, L. (2005). Correspondence from UNSW Educational Media Unit.

Howe, D. (2008). *Fundamental statistics for the behavioral sciences*. Belmont, CA: Thompson Higher Education.

International Civil Aviation Organization, (ICAO). (2001) Annex 13: Aircraft Accident and Incident Investigation (Ninth Edition). Montreal: ICAO.

Lewis, R., & Marrap, M. (2008). The development of a project-based learning and teaching paradigm at the Australian Defence Force Academy. In L. Mann, A..Thompson & P. Howard (Eds.), *Proceedings of the 2008 Australian Association for Engineering Education Conference*. Yeppoon: AaeE

Rigby, C., Deci, E., Patrick, B., & Ryan, R., (1992). Beyond the intrinsic-extrinsic dichotomy: self-determination in motivation and learning. *Motivation and Emotion, 16*(3), 165-185.