Global Journal of Engineering Education

A study of the validity of prerequisites in an aviation undergraduate curriculum

Hala Elnagar & Steven J. Thatcher

Abu Dhabi University
Abu Dhabi, United Arab Emirates

ABSTRACT: The authors of this article discuss the prerequisite courses that are required for the major courses in the Bachelor of Science in Aviation programme (BScA), where a mathematical background is essential. The article presents a study of the relationship between grade achieved in the new prerequisite course, Mathematics for Science and Technology (MTT 101) and grades achieved in two different aviation major courses in the BScA; namely, Aerodynamics (AVS 209) and Introduction to Meteorology (AVS 301). Grade performance for 169 undergraduate aviation students was determined for both the aviation major courses and the prerequisite course MTT 101. For comparison, the study used the grade performance of 109 undergraduate students to determine the relationship between grade achieved in the original prerequisite course, General Mathematics (MTG 100) and grades achieved in AVS 209 and AVS 301. It was found that there was a stronger correlation between MTT 101 and AVS 209 than between MTG 100 and AVS 209. It was also found that students performed better in the aviation courses than in MTT 101.

Keywords: Aviation programme, aviation studies, foundation courses, prerequisite courses, student performance,

INTRODUCTION

The second author, a cofounder of Australasia's first tertiary aviation programme and Australasia's first university owned flying school has described and discussed the historical development of the tertiary aviation discipline in Australia [1]. During the development of aviation programmes at the University of South Australia many educational methods were implemented to improve student learning [2-4]. The most significant development was a project to map the curriculum to determine if there were overlaps or gaps in the curriculum that would hinder student learning outcomes [5].

The authors currently teach at Abu Dhabi University (ADU), United Arab Emirates, which offers a BSc in Aviation (BScA), mainly to Etihad cadet pilots as part of Etihad's Cadet Pilot Programme. The structure of the four year BSc in Aviation includes a foundation year in ADU's University College (UC). The first year in UC provides students with prerequisite knowledge to progress in their chosen major, aviation, engineering, information technology, business or arts and sciences. This article presents a study of the validity of two foundation mathematics courses as prerequisites to two aviation majors.

The mathematics courses offered by Abu Dhabi University have several desired learning outcomes that can be divided into the broad categories of skills, knowledge and behaviours. Knowledge of the technical content of the course is the most obvious learning outcome of studying the courses, and is typically reflected in the course title and catalogue description. These learning outcomes are presented to the students in the syllabus as a list of topic specific learning outcomes. These topic lists provide a set of advance organisers upon which the students focus. This is reinforced with discussions on …*what will be covered in the examinations*. Just as critical, however, are the skills and behaviours that students are expected to develop during the course and throughout their academic career.

The authors of this article address the issue of prerequisite requirements in the academic career development of aviation students. The study discussed in this article was conducted at ADU in order to compare the relevance of the original prerequisite, General Mathematics (MTG 100), and the new prerequisite, Mathematics for Science and Technology (MTT 101), for the major courses in the BSc in Aviation. The study attempts to determine the relevance of prerequisite course topics to the desired skill development needed in the related major aviation courses and attempts to address the actual required learning outcomes.

In this article, the authors present and discuss the development and implementation of a prerequisite mathematics course, Mathematics for Science and Technology (MTT 101) and its impact on students' performance in the major courses in aviation. The article also reports on the content needs for the aviation majors in general. Particular emphasis is paid to how an enhanced prerequisite course approach differs from a traditional prerequisite course implementation. It will be seen that the more recent prerequisite course of *pre-calculus* mathematics for technology and engineering has a significant effect on the outcomes of the following major courses in aviation. These differences result from the comparison of students' performance in two of their major aviation courses according to the implementation of the traditional prerequisite mathematics course of General Mathematics (MTG 100) and the newer prerequisite course of Mathematical for Science and Technology (MTT 101).

ORIGINAL PREREQUISITE COURSE, GENERAL MATHEMATICS

The introductory General Mathematics course MTG 100 has many topics included in the syllabus. However, it was decided that it was important to include additional topics in the course, such as trigonometry, angles, functions, applications. Without these additional topics, a student could not be expected to understand and complete some of the second year courses in aviation, such as Aerodynamics or Aircraft Performance.

The current syllabus for the General Mathematics (MTG 100) course includes the following topics:

- Linear equations and inequalities in one variable: the addition and multiplication properties of equality, solving general linear equations, more equations and inequalities, solving inequalities and applications;
- Linear equations in two variables and their graphs: graphing lines in the coordinate plane, slope, equations of lines in slope-intercept form, the point-slope form;
- Exponents and polynomials: the rules of exponents, negative exponents, scientific notation, addition and subtraction of polynomials, multiplication of polynomials, multiplication of binomials, special products, division of polynomials;
- Factoring: factoring out common factor, special products and grouping, factoring the trinomial, difference and sum of cubes, solving quadratic equations by factoring;
- Rational expressions;
- System of linear equations;
- Quadratic equations, functions and inequalities.

These topics are essential in order to provide a general knowledge background in mathematics for courses in programmes, such as law or general education, but courses in programmes, such as engineering and aviation require a more advanced mathematical background. A further complication with the general mathematics course is that students view the course as an eclectic mix of disconnected and unrelated topics, without any relevance to further study in their major courses. Students often say …*today we are covering xyz*, …*we will not need this after the examination*. This is despite the course lecturers viewing the topics are highly connected and related and relevant to the students' further study in their major. But, in reality, and while lecturers view the course topics as being related and highly connected, sometimes the delivery method does make the topics seem unrelated and disconnected, and this aids the students' belief that they …*will never need to know or use this material again* after the class is over. All of this lead to the conclusion by faculty that more topics needed to be added to the General Mathematics course to make it more relevant for future courses. To achieve this the course of general mathematics was replaced with Mathematics for Science and Technology (MTT 101).

NEW PREREQUISITE COURSE, MATHEMATICS FOR SCIENCE AND TECHNOLOGY

It was decided that Mathematics for Science and Technology (MTT 101), also known as pre-calculus mathematics or algebra with trigonometry based mathematics in other universities, was a more appropriate way to satisfy the fundamental knowledge requirements of the major courses in aviation. As a consequence, MTT 101 was added as the mathematics prerequisite for some of the aviation majors instead of MTG 100. The additional topics covered in the MTT 101 course are based on pre-calculus trigonometry and its applications. The topics included in MTT 101 are shown in the list below:

- Angles and their measure;
- Solving right triangles;
- Properties of trigonometric functions;
- More general trigonometric functions (graphs);
- Inverse of trigonometric functions basic identities and their use;
- Sum and difference identities;
- Double-angle and half-angle identities;
- Product-to-sum and sum-to-product identities;
- Trigonometric equations;
- Law of sines;
- Law of cosines.

These topics give students the background to tackle more realistic problems in aerodynamics and are needed as a foundation for further study in the aviation programme.

CORRELATION ANALYSIS BETWEEN PERFORMANCE IN GENERAL MATHEMATICS, AND AERODYNAMICS AND INTRODUCTORY METEOROLOGY

A convenience sample of 109 undergraduate aviation students that had studied and received a grade in MTG 100, AVS 209 and AVS 301, was used for this part of the study. Pearson's *r* correlation coefficients were calculated for the relationship between the performance of students in two aviation courses Aerodynamics (AVS 209) and Introductory Meteorology (AVS 301), and the original prerequisite MTG 100.

The correlation coefficients between the MTG 100 course and each of the aviation courses, AVS 209 and the AVS 301, were 0.332 and 0.421, respectively (Table 1).

Table 1: Pearson's r correlation coefficient between MTG 100 and, AVS 209 and AVS 301.

	AVS 209	AVS 301
MTG 100	0.332 Sig. (2-tailed) 0.000	0.421 Sig. (2-tailed) 0.000

Both correlation coefficients reveal a moderate correlation that is significant at $\alpha = 0.01$ level.

These are moderate levels of correlation for both correlation coefficients [6]. Scatter graphs were plotted to visually examine the relationship between MTG 100 and AVS 209, and MTG 100 and AVS 301. Visually, the correlation did not seem high for either of the scatter graphs (Figure 1).

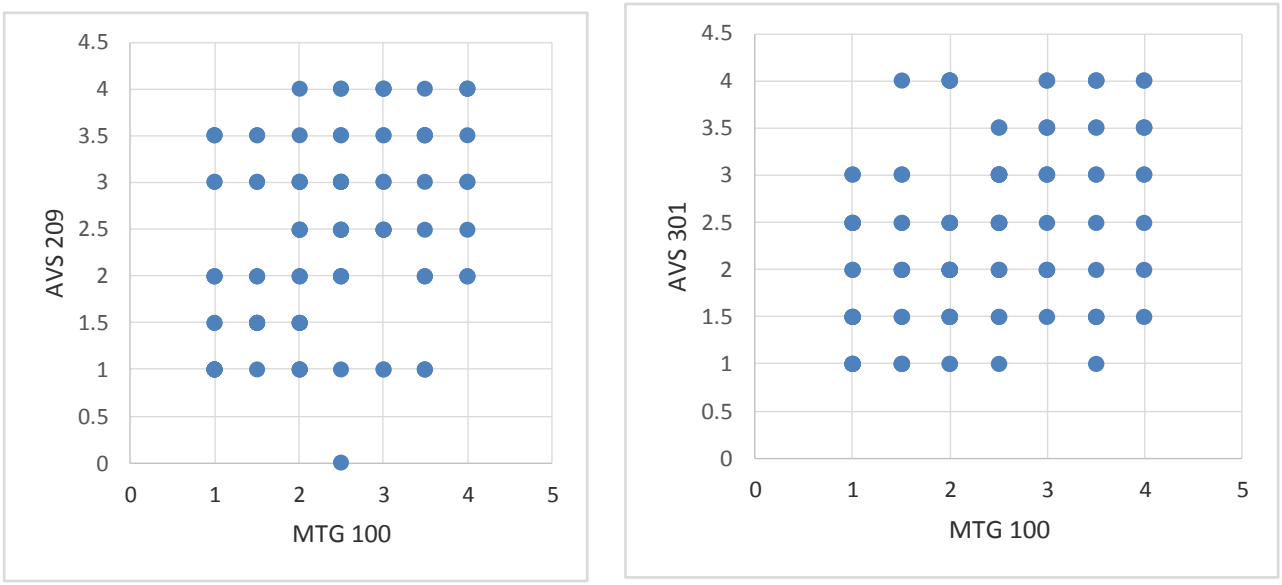

Figure 1: Scatter graphs of the relationship between MTG 100 and AVS 209, and MTG 100 and AVS 301.

A paired-sample *t*-test was also performed on the same data sample of 109 students that were graded for MTG 100, AVS 209 and AVS 301 to see if there was any significant difference in performance between MTG 100 and AVS 209, and MTG 100 and AVS 301. The results can be seen in Table 2.

Table 2: Paired-sample *t*-test for MTG 100 and AVS 209, and MTG 100 and AVS 301.

		Paired differences					*t*	df	Sig. (2-tailed)
		Mean	Std. deviation	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair 1	MTG 100 - AVS 209	-0.03670	1.11535	0.10683	-0.24846	0.17506	-0.344	108	0.732
Pair 2	MTG 100 - AVS 301	-0.05046	1.00679	0.09643	-0.24161	0.14069	-0.523	108	0.602

Looking at Table 2, it can be seen that there is no significant difference between the grade point means of MTG 100 and AVS 209.

CORRELATION ANALYSIS BETWEEN PERFORMANCE IN MATHEMATICS FOR SCIENCE AND TECHNOLOGY, AND AERODYNAMICS AND INTRODUCTORY METEOROLOGY

After the implementation of the new prerequisite Mathematics for Science and Technology, MTT 101, for the same two aviation courses, Aerodynamics, AVS 209, and Introductory Meteorology, AVS 301, a convenience sample of 163 undergraduate aviation students that had received grades in MTT 101, AVS 209 and AVS 301 was selected as part of this study. Pearson's *r* correlation coefficients were calculated for the relationship between the performance of students in the two aviation courses Aerodynamics (AVS 209) and Introductory Meteorology (AVS 301), and the new prerequisite MTT 101. The correlation coefficients between the MTT 101 course and each of the AVS 209 and the AVS 301 were 0.524 and 0.450, respectively (Table 3). Scatter graphs were plotted to visually examine the relationship between MTT 101 and AVS 209, and MTT 101 and AVS 301. Visually, the correlation only seemed reasonably high for the relationship between MTT 101 and AVS 209 (Figure 2).

Table 3: Pearson's *r* correlation coefficient between MTT 101 and, AVS 209 and AVS 301.

	AVS 209	AVS 301
MTT 101	0.524 Sig. (2-tailed) 0.000	0.450 Sig. (2-tailed) 0.000

The relationship between MTT 101 and AVS 209 revealed a strong correlation and the relationship between MTT 101 and AVS 301 revealed a moderate correlation. Both correlation coefficients were significant at $\alpha = 0.01$ level.

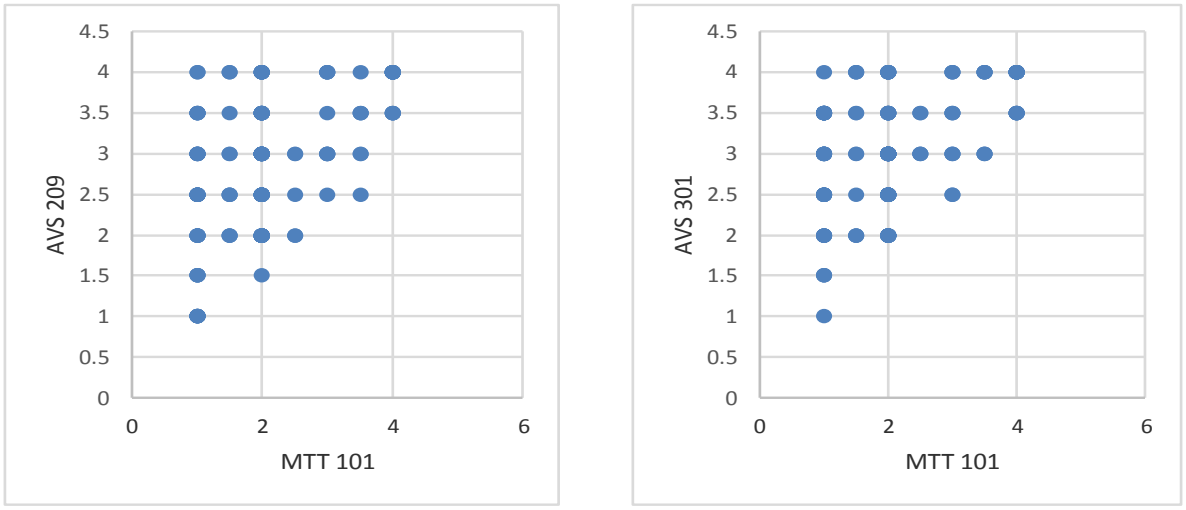

Figure 2: Scatter graphs of the relationship between MTT 101 and AVS 209, and MTT 101 and AVS 301.

A paired-sample *t*-test was also performed on the same convenience data sample of 163 student performances in AVS 209 and AVS 301 with MTT 101 as a prerequisite to determine if there was any significant difference in the mean performance between MTT 101 and AVS 209, and MTT 101 and AVS 301. The results can be seen in Tables 4.

Table 4: Paired-sample *t*-test for MTT 101 and AVS 209 and MTT 101 and AVS 301.

		Paired differences					*t*	df	Sig. (2-tailed)
		Mean	Std. deviation	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair 1	MTT 101 - AVS 209	-0.73313	0.86117	0.06745	-0.86633	-0.59993	-10.869	162	0.000
Pair 2	MTT 101 - AVS 301	-0.92638	0.87000	0.06814	-1.06094	-0.79182	-13.595	162	0.000

Looking at Table 4 it can be seen that there is a significant difference between the grade point means of MTT 101 and AVS 209. There is also a significant difference between the grade point means of MTT 101 and AVS 301. Both of these differences between the means are significant at $\alpha = 0.01$. Further, the mean grade performance in MTT 101 was significantly worse than the grade performance in either AVS 209 or AVS 301.

DISCUSSION

Students traditionally find MTT 101 difficult and the results reflect this. Many students fail MTT 101 and, as a consequence, they cannot proceed to enroll in all the freshman year courses in aviation. This causes the students to

choose courses from the junior and senior years ahead of when they should be taking them. However, students taking courses *out of order* leads to problems as students find they get behind with their studies by a minimum of one year. This motivates students to request prerequisite waivers to Aerodynamics or Introductory Meteorology without the required prerequisite. Some students ask for MTT 101 and AVS 209 to be taken as co-requisites. This has been approved in the past, because students have been inconvenienced by programme structural changes, but it is unlikely to continue. The performance of students in AVS 209 and AVS 301, when they have failed MTT 101, has provided valuable data for this study.

The question that arises from this is *…should MTT 101 be retained as the prerequisite or should MTG 100 be re-installed as the prerequisite?* Results of the study showed that the correlation between MTT 101 and AVS 209 was strong, whereas the correlations between MTT 101 and AVS 301, MTG 100 and AVS 301 and MTG 100 and AVS 209 was moderate. Therefore, it is reasonable to say that good performance in MTT 101 will indicate that a student will perform well in AVS 209. Also, a student who performs poorly in MTT 101 will also perform poorly in AVS 209. So, MTT 101 is a good predictor of success in the rest of the BSc in Aviation. But, should it be a prerequisite?

Results from the paired-samples *t*-test showed that students performed much better in the aviation courses than MTT 101, but performed the same in MTG 100 as the aviation course. Therefore, a good score in MTT 101 will predict an even better score in AVS 209 and AVS 301. As a consequence, MTT 101 is a useful course to screen out weaker students from the aviation major.

CONCLUSIONS

The authors suggest that to ensure the success of the aviation programme, the aviation programme should incorporate realistic prerequisite courses, where the lecturer makes explicit connections between prerequisite and major courses.

The authors further recommend that students should understand that a prerequisite course is not meant to primarily serve as a tool to master the basic concepts in mathematics, but rather to serve to tie different concepts together to provide a foundation for the major courses in aviation. Moreover, MTT 101 has proved useful in screening out the weaker students from entering the major courses at an earlier stage of their degree. But, further analysis is required to determine if replacing MTG 100 with MTT 101 was beneficial to students in general.

REFERENCES

1. Thatcher, S., The development of a new discipline in aviation education and training at the University of South Australia, *Proc. 5th Global Cong. on Engng. Educ.*, New York, USA, 17-21 July, 85-88 (2006).
2. Thatcher, S., Scenario-based learning and assessment for second year aviation students. *Global J. of Engng. Educ.*, 11, **2**, 123-133 (2007).
3. Thatcher, S., Experiential learning and the classification of team skills in pilot education. *World Trans. on Engng. and Technol. Educ.*, 6, **2**, 271-274 (2007).
4. Thatcher, S.J. and Tsui, K.W.H., A comparison of the learning outcomes of international students from Asia and Australian students in an undergraduate aviation programme. *World Trans. on Engng. and Technol. Educ.*, 11, **4**, 456-459 (2014).
5. Thatcher, S., Mapping the aviation curriculum. *Inter. J. of Technol. and Engng. Educ.*, 6, **1**, 5-10 (2009).
6. Pearson's Correlation. Stats Tutor, 31 March 2016, http://www.statstutor.ac.uk/resources/uploaded/pearsons.pdf

BIOGRAPHIES

Hala Elnagar is a senior Instructor for Mathematics and Statistics and the Math and Science programme director at the University College, Abu Dhabi University, United Arab Emirates. She was also selected and appointed to serve as the coordinator of the Learning Support Centre and the coordinator for the Math Placement Test. Ms Elnagar received her BSc in Structural Engineering from Ain Shams University in Cairo, Egypt (June 1984); and received her MSc in Civil Engineering (Structures and Construction Management) from Polytechnic Institute of New York University, USA (May 1993). Ms Elnagar served as Math and Statistics part time faculty at the Maine Maritime Academy, Maine, USA, between 2003 and 2005 before joining the University College at Abu Dhabi University in September 2008. Ms Elnagar's primary areas of research activities are Construction Management and Teaching Effectiveness. She published an article titled *Construction Documentation used as Indicators of Delays* in the Cost Engineering Journal in the early 1997, and presented an article titled *Effective Grading and Creativity in Teaching in the 21st Century* in the GCC conference at Abu Dhabi University, March 2015. Ms Elnagar also contributes to several activities in the Abu Dhabi Community. She was an active member of the American Community School ACS of Abu Dhabi Board of Trustees (2013-2015) and selected to be the chair of the curriculum committee. Ms Elnagar was also the chair of the graduation committee of ACS for the class of 2013 and the class of 2015.

Steve Thatcher is the Inaugural Chair of Aviation at Abu Dhabi University (ADU) in Abu Dhabi, UAE. He is also the Inaugural Professor of Aviation at ADU and an Adjunct Professor at Central Queensland University. Steve works in partnership with Etihad Airlines to provide Etihad cadet pilots the opportunity to study a Bachelor of Science in Aviation. Previously, Steve was a founding member of the team that introduced Australasia's first tertiary award course in Aviation in 1985 at the University of South Australia's (UniSA) antecedent institution the South Australian Institute of Technology. This established the aviation discipline in the Australasian region. Steve was also a founding member of the team that established the University's Aviation Academy in 1990 becoming the first university in Australasia to own and operated a flight training school. Steve was also a founding member of the Australasian University Aviation Association. Serving as Secretary for a number of years. In 2005, Steve successfully negotiated the SA Government Fixed Wing Shark Patrol Service for UniSA Aviation. UniSA Shark Patrol provides a valuable community service and has provided graduate pilots with valuable flight time experience at a stage in their careers when it is relatively difficult to get flight experience. Steve recently won the Chancellor's Award for Community Engagement for the UniSA Shark Patrol. Steve has qualifications in Physics, Psychology, Education, Computer Systems Engineering and Aviation. He has been a Jackaroo in South West Queensland, a Mechanical Engineer for British Aerospace (UK) and has lectured in Physics, Electronics and Aviation. He holds a Commercial Pilot Licence and a Grade One Instructor Rating. Steve is on the Editorial and Review Boards of several journals and international conferences. Steve has won the UICEE's Silver Badge of Honour for distinguished contributions to engineering education, outstanding achievements in the globalisation of engineering education through the activities of the Centre, and, in particular, for remarkable service to the UICEE.