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Learning secondary mathematics with technology: Exploring the complex interrelationship between students' attitudes, engagement, gender and achievement

Anastasios (Tasos) Barkatsas [a,*], Katerina Kasimatis [b], Vasilis Gialamas [c]

[a] Monash University, Northways Road, Churchill, Victoria 3842, Australia
[b] School of Higher Pedagogical and Technological Education, Greece
[c] National and Kapodistrian University of Athens, Greece

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ABSTRACT

The aim of this study was to investigate the complex relationship between students' mathematics confidence, confidence with technology, attitude to learning mathematics with technology, affective engagement and behavioural engagement, achievement, gender and year level. The participants were secondary students from state co-educational schools in Metropolitan Athens, Greece. Gender differences as well as differences between year levels and the resulting clusters of students were investigated by using a MANOVA. It was found that boys expressed more positive views towards mathematics and more positive views towards the use of technology in mathematics, compared to girls. It was also found that high achievement in mathematics was associated with high levels of mathematics confidence, strongly positive levels of affective engagement and behavioural engagement, high confidence in using technology and a strongly positive attitude to learning mathematics with technology. Low levels of mathematics achievement was associated with low levels of mathematics confidence, strongly negative levels of affective engagement and behavioural engagement, low confidence in using technology, and a negative attitude to learning mathematics with technology.

The *mathematics and technology attitudes scale* (MTAS) developed by Pierce, Stacey, and Barkatsas (2007) was used to examine the role of the affective domain in learning mathematics with technology, and it reports the results from the use of MTAS in year 9 and 10 classrooms in Athens, Greece. According to the scale developers (Pierce et al., 2007) MTAS can be used in schools which aim to track changes in the attitudes and engagement of students in their learning of mathematics, in response to the altered learning environment and to consider how best this use of technology can be implemented. Pierce et al. (2007) claimed that:

> For learning and doing mathematics, technology in the form of 'mathematics analysis tools' (such as certain computer software, calculators, graphics calculators, computer algebra systems, spreadsheets, statistics programs) can assist students' problem solving, support exploration of mathematical concepts, provide dynamically linked representations of ideas and can encourage general metacognitive abilities such as planning and checking... With substantial investment in providing information technology to assist in teaching and learning mathematics, it is important to monitor students' reactions and decide how best to use both forms of technology, the mathematics analysis tools and the real world interfaces (p. 286).

Reports of a number of teaching innovations of the last thirty years include data on students' attitudes to the innovation as well as their mathematical achievement. McLeod (1992) put forward a strong position that affective issues play a central role in mathematics learning. McLeod (1992) definition of beliefs has been considered adequate for this study, since it makes clear the distinction between the cognitive and affective dimensions of beliefs:

> Beliefs are largely cognitive in nature, and are developed over a relatively long period of time. Emotions, on the other hand, may involve little cognitive appraisal and may appear and disappear rather quickly, as when the frustration of trying to solve a hard problem is followed by the joy of finding a solution. Therefore we can think of beliefs, attitudes and emotions as representing increasing levels of affective involvement, decreasing levels of cognitive involvement, increasing levels intensity of response, and decreasing levels of response stability. (p. 579).

* Corresponding author. Tel.: +61 3 99026354; fax: +61 3 99016361.
E-mail address: Tasos.Barkatsas@education.monash.edu.au (Anastasios (Tasos) Barkatsas).

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Student engagement with the intellectual work of learning is, according to Marks (2000), an important goal for education, leads to achievement and "contributes to students' social and cognitive development" (p. 154). In this paper it is argued that engagement, mathematics confidence, confidence with technology and achievement are interrelated, as far as high achievers in secondary school mathematics are concerned. Marks (2000) claimed that.

> Although research examining effect of engagement on achievement is comparatively sparse, existing studies consistently demonstrate a strong positive relationship between engagement and performance across diverse populations. (p. 155).

This claim is supported by the results of the cluster analysis results in this study.

There are a number of theories of student engagement. A theory of student academic engagement has been articulated by Newmann (1989). The researcher proposed three dimensions of student engagement: (1) students' need to develop and express competence, (2) students' full participation in school activities, and (3) students being immersed in authentic academic work. It is believed that most students commence their school life being inherently motivated but for many of them this motivation diminishes or entirely disappears, because the students are involved in routine and boring activities and they try to get by with as little effort as possible.

Fredricks, Blumenfeld, and Paris (2004) assumed that school engagement as a concept that is malleable, responsive to contextual features and amenable to environmental change. They claimed that research literature considers engagement as a multidimensional concept or even as a "meta" construct. They proposed the following three dimensions: *behavioural engagement*, which draws on student participation, *emotional engagement*, encompassing both positive and negative reactions to staff and the school in general, and (3) *cognitive engagement*, which draws on the principle of students making an investment in learning (p. 60). Only two of the dimensions of this framework, i.e. behavioural engagement and emotional engagement form part of the MTAS instrument. Zyngier (2007) however, claimed that:

> Much of the research essentializes engagement, portraying engagement and its supposed concurrent academic success as a function of the individual, ignoring the contribution of gender, socio-cultural, ethnic and economic status (class) factors. (p. 331).

Zyngier (2007) proposed that there are three dominant perspectives which could be conceptualised to account for engagement from a social justice point of view: (i) the instrumentalist or rational technical, (ii) the social or individualist and (iii) the critical transformative engagement.

Middleton (1999) put forward a number of reasons that provide a rationale as to why intrinsic motivation for achievement in mathematics is desirable in contemporary mathematics classrooms. He claimed that:

> When students engage in activities in which they are intrinsically motivated they tend to exhibit a number of pedagogically desirable behaviours including time on task, persistence in the face of failure, more elaborative and monitoring of comprehension, selection of more difficult tasks, greater creativity and risk taking, selection of deeper and more efficient performance and learning strategies, and choice of an activity in the absence of an extrinsic reward (p. 66).

The researcher also argued that intrinsic motivation is more complex than the additive effects of student ability, perceived competence and achievement desire, even though they significantly contribute to the students' desire to successfully participate in mathematical activities and to do well in mathematics. Newmann (1989) however, adopted a somehow different position. He argued that "only when students perceive that academic achievement will lead to rewards they value and, further, believe that their own hard work will result in academic achievement will their engagement increase" (p. 35).

The importance of intrinsic motivation for achievement and participation in advanced mathematics courses, and the apparent differences between boys and girls' views has been demonstrated by Watt's (cited in Vale & Bartolomew, 2008) argument that:

> Boys maintained higher intrinsic value for maths and higher maths-related self-perceptions than girls throughout adolescence... We need to understand how it is that boys come to be more interested and like maths more than girls; and also why girls perceive themselves as having less talent, even when they perform similarly.

The authors also cited a finding from the program of international student assessment (PISA) 2003 study relating to female students' confidence in mathematics: "females appear to be less engaged, more anxious and less confident in mathematics than males. It is our contention however, that computer (and technology) confidence is a very different construct to that of mathematical confidence. Mathematical confidence is an affective dimension closely associated with mathematics achievement.

Weglinsky (1998) evaluated the educational technology and student achievement in mathematics with a USA national sample of 7, 146 year 8 (second year junior high school) students. He reported the following findings: (1) year 8 students who used technology (simulation and higher order thinking software) gained up to 15 weeks above grade level or about one-third of a year level increase, in mathematics scores. He also reported that "high-achieving students are more likely to use technology in certain ways rather than these uses of technology promote high levels of academic achievement" (p. 4).

The role of motivation, intrinsic values and gendered mathematics related self-perceptions were considered by Watt (2006) as the major influences on: "gendered educational participation in senior high school maths, which subsequently predicted maths-related career aspirations-over and above prior mathematical achievement" (p. 305).

1. Aims of the study

The aims of the study were:

- To investigate the factorial structure of the following variables: secondary students' mathematics confidence, confidence with computers, attitude to learning mathematics with computers, affective engagement and behavioural engagement.
- To investigate the influence of demographical data and biodata on students' mathematics confidence, confidence with technology, attitude to learning mathematics with computers, affective engagement and behavioural engagement.
- To investigate the interrelationship between the attitude, engagement, confidence and achievement variables.