Second Chance Learners, Supporting Adults Learning Computer Programming

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***Abstract* - The focus of this paper is adult learning, with regard to understanding how adults learn computer programming. Some computing students learning programming for the first time often have ineffective mental models for how a program operates and they fail to transfer their programming knowledge beyond what is taught. They lack appropriate cognitive skills that are a prerequisite to learning computer programming, and have a mental block when it comes to understanding the abstract constructs involved. This can cause the students to become anxious, or even fear programming. As performance is negatively affected by anxiety, this consequently impacts on their academic performance. This paper explores programming anxiety and the construction of mental schemas necessary for learning computer programming.**

Index Terms – Computer Programming, Mental Schema, Anxiety.

INTRODUCTION, ADULT LEARNING

Negative cognitions and attitudes to learning a new skill generally accompany such feelings of anxiety, including worry about embarrassment and looking foolish. It is hypothesized that students' introductory computer programming courses are perceived by some first year students as demanding and stressful because of the abstract and complex components involved. Computer programming is an ab-initio skill for the majority of first year undergraduate students and their mental schemas necessary in programming may not be developed sufficiently, but particularly apparent for adult learners. Studies have investigated the factors that indicate student's ability to learn programming which include mathematical ability, processing capacity, analogical reasoning, conditional reasoning, procedural thinking and temporal reasoning [1] and some of these skills are underdeveloped prior to the student starting their undergraduate computing degree programme, causing them enter a state of apprehension and unease. It is felt that a situation specific anxiety occurs for students when they have to learn programming for the first time. This anxiety, Programming Anxiety, is a constituent of computer anxiety and occurs for students when a mistaken or dysfunctional assessment of their ability to learn computer programming occurs.

This paper will firstly explain anxiety and defines how programming anxiety occurs for computing students. Results from research conducted at Dundalk Institute of Technology presents the prevalence of programming anxiety amongst first year undergraduate students. The paper concludes in examining how adults learn and the necessity for creating learning strategies to overcome programming anxiety.

COMPUTER AND PROGRAMMING ANXIETY

Anxiety is a feeling of apprehension or fear, it is a complex phenomenon which may be a generalized personality trait for some individuals, while for others it is quite clearly context bound and stressful in particular situations [2, 3]. Anxiety may be distinguished from fear in that the former is an emotional process while fear is a cognitive one [4]. When fear becomes activated one experiences anxiety, and prolonged anxiety can lead to a state of stress [2].

Computer anxiety prevents students from learning the simplest of computing task, as it has been found that negative feelings and attitudes intrude on the development of formal reasoning. It is suggested that in some circumstances test anxiety and computer anxiety bear similar characteristics [5]. It has been demonstrated that computer anxiety is an important predictor of student achievement in computing skills [6]. Furthermore, the higher the initial level of computer anxiety, the lower the computer achievement [6]. In developing a standardized test of computer anxiety, the Computer Anxiety Index (CAIN) similarly demonstrated that students with higher computer anxiety scores had lower scores on an achievement test of computer literacy [7]. Speier found significant correlation between high initial levels of anxiety and decreased skills performance throughout computer learning [8]. Honeyman concluded that students perform more poorly and develop negative attitudes as a result of computer anxiety [9].

Among the early literature on the psychological state of individuals who have negative affective reactions to computers, researchers in the area of computer anxiety suggested that a major influence is the lack of familiarity with computers [10], and with increased experience anxiety should decrease. The subsequent research gave some support to this hypothesis [11]. However Rosen et al. argued, in contrast, that during repeated exposure to the computer, the subject is being reconditioned at increased levels of anxiety which, thus increases discomfort and anxiety [12-14]. In conclusion, they found that experience with computer interaction did not reduce computer anxiety nor improve attitudes [13, 14]. Marcoulides concluded that computer anxiety significantly influences the degree to which computers can be utilized effectively by third level students and that although computer experience does diminish the

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anxiety to some extent, varying degrees of computer anxiety remain [6]. Corroboration for such assertions comes from Mahmood who found that even after an extensive computer literacy course, initial negative attitudes and values towards computer technology persisted, though somewhat diminished [15]. Similarly Leso reported that in both computer applications and programming courses, significant numbers of students reported anxiety at the end of fourteen weeks, one third in the former case, and over two-thirds in the latter [16], despite the fact that most students had prior computer experience. This affirmed simply but pointedly, that such courses alone do not guarantee reduction in anxiety for all individuals [16]. It is clear from this literature, that computer anxiety is prevalent and can persist in individuals irrespective of exposure to computers [17].

Meier believes that computer anxiety can be understood within a social learning model and is a result of low expectations of efficacy, outcome or reinforcement [18]. Therefore, anxiety and related components maybe made better or more tolerable by enhancing self-efficacy through skill building and success experiences. Another review was presented by Rosen and Weil who perceived computer anxiety as a clinical entity wherein anxiety may vary anywhere from mild discomfort to severe 'phobia', [13, 14]. The cause of such phobia is prior uncomfortable computer interactions which make future computer and even mechanical experiences appear to be negative regardless of their outcome [19] and may perhaps lead to withdrawal from educational courses. An intervention for computer related anxieties needs to be strategic and may include the use of desensitization, relaxation and analytic interventions [20, 21].

In this research, it is hypothesized that students' introductory computer programming courses would be perceived by some first year students as demanding and stressful especially due to the abstract and complex components involved. As such, programming anxiety, a form of computer anxiety would occur (as depicted in Figure 1). For the purpose of this research, originating from McInereny's definition of computer anxiety, programming anxiety is proposed as "a psychological state engendered when a student experiences or expects to lose self-esteem in confronting a computer programming situation."

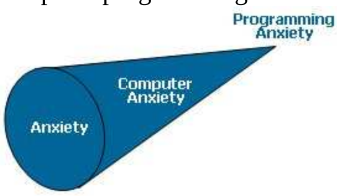

FIGURE 1
RELATIONSHIP BETWEEN ANXIETY, COMPUTER ANXIETY AND PROGRAMMING ANXIETY

Anxiety is maintained by mistaken or dysfunctional appraisal of a situation and therefore programming anxiety occurs for students because of a mistaken assessment of their ability to learn computer programming. This mistaken assessment can be because the process of activation cannot take place, and the students' mental schemas cannot form the foundation from which they will deconstruct the programming problem and develop a solution. The cognitive model conceives that when people find themselves in situations, automatic thoughts are activated, which are directly influenced by their core and intermediate beliefs. Automatic thoughts then influence reactions. A students most fundamental beliefs impact their thoughts in given situations. For a student susceptible of computer programming anxiety, their core belief, a fear of learning programming may commence when they first engage in learning this new computer programming skill. Their intermediate thoughts could arise as a fear of what other students might think. The automatic thought occurs when the student is in the influential environmental and combined with their beliefs and trigger negative thoughts and reactions.

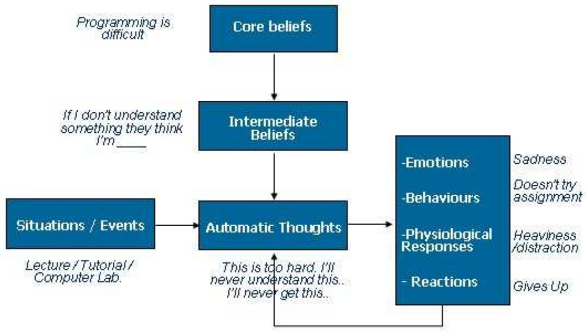

FIGURE 2
THE COGNITIVE MODEL [4] AMENDED FOR PROGRAMMING ANXIETY

This notion of a mismatch between internal/individual demands and resources is central to the majority of anxiety conceptualizations. The subjective appraisal of a demanding environment, a realization that demands may outstrip resources and that the consequences of not coping, are important in defining programming anxiety in the higher educational environment. Corresponding to the mismatch between skill and challenge relationship in gaining 'optimal experience' [22]. It is key to ensure that the students are anxious to learn programming but not anxious about learning.

PROGRAMMING ANXIETY PREVALENCE AMONG FIRST YEAR COMPUTING STUDENTS

Research carried out at Dundalk Institute of Technology, Ireland shows that there are high levels of programming anxiety evident amongst the first year undergraduate computing cohort [23].

The evaluation cycles took place during the 2005/2006 Academic Year and 79% of the first year total participated in the initial Pre-CPAQ, (N = 86). Of the sample from whom data was collected 74 were male and 12 female. While many respondents used their personal computer for a variety of applications, programming was selected by only 7% of the students. 52.3% of students indicated that they were Intermediate in terms of computer experience and 46.5% said they were Advanced. There wasn't a significant relationship between PC ownership and computer experience, with the majority of students who did not own a computer claiming they were Intermediate in terms of computing experience. Of the 12 female students, 11 indicated they were either Intermediate or Advanced, with one selecting Beginner. Students indicated that they were performance rather than learning oriented. 64% of students

(N=55) had chosen the course they were registered on as their first choice of degree programme at higher education. Of the 36% who had not chosen the course as their first preference, 50% had intended registering on a different computing degree course. The student demographics indicate their interest in computers and the range of experience in use of computers is vast across a broad range of applications.

The first scale of the Computer Programming Anxiety Questionnaire administered, Gaining Initial Computer Skills, refers to experiences related to computers, and students were asked to indicate the extent to which the situations described would make them anxious at this point in their life. It is clear that all students at the start of their third level education express considerable anxiety, with the greatest anxiety shown in the area of demonstrating Competence with Computers, which decreased considerably by the end of the semester.

Two factors relating to Positive and Negative Sense of Control when using a computer were identified. The factors reflect an individual's sense or lack of personal control, as indicated in their cognitions. Students Positive Sense of Control in computing situations decreased by the end of their first year at college. Their Negative Sense of Control on the other had increased, shown in Table 1.

With regard to Computer Self Concept, and for each of the two factors Positive Computing Self-Concept and Negative Computing Self Concept, questions assessed different responses in relation to student self-efficacy or confidence in computing. Students positive Computing Self Concept decreased at the end of the year and their Negative Computing Self Concept decreases, indicating that they have more negativity with regard to self confidence in a computing situation at the end of the year.

The fourth scale, 'State of Anxiety in Computing Situations' examined the cognitive, emotional and physiological states of anxiety students may face in computer programming situations and the results reflect an individual's level of state anxiety. The difference in pre and post results of the student cohort is interesting. All students indicated that their sense of Worry increased in the post-CPAQ. With regard to Happiness students answers in the post-CPAQ were slightly more negative compared to their answers in the pre-CPAQ. Students Physiological Symptoms and Distractibility remained the same with minimal changes in the distribution.

TABLE 1
MEDIAN AND INTERQUARTILE RANGE FOR COMPUTER PROGRAMMING ANXIETY QUESTIONNAIRE, PRE AND POST RESULTS

	PRE		POST	
	Median	IQR	Median	IQR
GAINING INITIAL COMPUTING SKILLS				
Competence with Computers	2.28	1.14	1.71	1.28
Handling Computer Equipment	1.50	3.00	1.25	2.50
Receiving Feedback on Computing Skills	1.80	1.80	1.40	2.00
Learning about Computer Functions	2.08	1.66	1.58	2.83
SENSE OF CONTROL				
Positive Control	3.92	1.10	3.50	3.32
Negative Control	1.27	0.55	1.50	0.77
COMPUTING SELF CONCEPT				
Computing Self Concept (positive items)	1.75	0.75	1.66	1.66
Computing Self Concept (negative items)	4.60	1.00	4.20	1.70
STATE OF ANXIETY IN COMPUTING SITUATION				
Worry	1.04	0.37	1.16	0.68
Happiness	4.00	0.87	3.50	0.93
Physiological Symptoms	1.00	0.35	1.00	0.20
Distractibility	1.00	1.00	1.00	0.37

The results from the research show students entering first year undergraduate computing courses have computer programming anxiety tendencies at the start of term, some of which diminish throughout their first year at college. Rather surprisingly student's negative sense of control or self-talk increases and their fear increases and their negative self-concept becomes more apparent by the end of first year. Anxiety in computing situations doesn't improve, with the student's sense of worry increasing and their sense of happiness decreasing. Student's positive self-concept improves in post analysis, but their positive sense of control (positive cognition) doesn't improve. These findings highlight important information with regard to the psychological stance of the students and their reaction to programming.

ADULT LEARNERS LEARNING PROGRAMMING

The basic principles of learning applied to children are as relevant in relation to adults learning new skills/material, as children. The differences are of emphasis rather than fundamental principle. Research has shown the two distinguishing characteristics of adult learning most frequently advanced by theorists are firstly the adults autonomy of direction in the act of learning and secondly the use of personal experience as a learning resource [24].

Effective self-regulated learning is linked to an adult's subscription to a self-concept of themselves as a learner. In his overview on self-regulated learning and achievement, Zimmerman, defines self-regulated learners as metacognitively, motivationally, and behaviorally active participants in their own learning. In terms of motivational processes, these learners report high self-efficacy, self-attributions and intrinsic task interest [25]. As a rule, adult learners like their learning activities to be problem centered and meaningful to their life situation, and they want the learning outcomes to have some immediacy of application. One therefore can assume that adults seem to learn best when they do not rely on memorizing, but when they can learn through activity at their own pace, with material that is relevant to their daily lives and can utilise their own experience. It is also important to recognize however that self-direction in learning is not an empirically verifiable association of adulthood and that there are many individuals who are chronologically adult, but who show a reluctance to behave in a self-directed manner.

The past experiences of adults affect their current learning, sometimes serving as an enhancement or hindrance [26]. In higher education it is vital that the students past experiences and prior knowledge are encompassed in their learning. Prior knowledge is also referred to as 'declarative' knowledge [27], and refers both to the quantity of knowledge (what is known) and the quality of knowledge (how well it is known, organized and structured) [28]. Of importance to this research, is the way in which students' prior knowledge is organized and structured. Bransford suggests that the effective use of cognitive and metacognitive strategies can assist in the appropriate organization of knowledge and therefore in its effective retrieval and application [29]. Well structured knowledge is easily and spontaneously accessed, supported by many internal and external connections [30] and through the activity of schemas and scripts, act as a guide to comprehension, inference, reasoning and problem solving.

INFORMATION PROCESSING AND MENTAL MODELS

Information Processing is a theory of learning that explains how stimuli enter one's memory system, are selected and organized for storage and retrieved from memory [30, 31]. In order to design and develop an appropriate approach for students susceptible of programming anxiety, to construct a mental model for learning programming, an awareness of how students process information is important. Information processing, a common theoretical approach used by cognitive psychologists, is not simply a unified theory, but rather an approach to understanding human knowledge and action. The approach analyses cognitive processes in a sequence of ordered stages; each stage reflecting an important step in the processing of cognitive information [32]. Meaningful learning occurs during information processing when the student connects new material with knowledge already existing in memory. The existing knowledge in memory is called a schema [33, 34].

As experience is acquired, one is forced to adapt to function effectively. Adaptation is the process of adjusting schemas and experiences of each other to maintain equilibrium, and consists of two reciprocal processes: accommodation and assimilation. Accommodation is a form of adaptation in which an existing schema is modified and a new one is created in response to the experience. The latter assimilation is the process of connecting new information to an existing schema [33, 34]. If new experiences are only assimilated into existing schemas, the schemas won't change and development doesn't occur. On the other hand, if existing schemas can't be made to work, a person faces constant disequilibrium.

The concept of mental schemas has been used in a number of research areas as an effective and insightful approach to studying the behaviors and beliefs of individuals and organizations. Schemas are abstract mental records that serve as guides to action, as structures for remembering and interpreting information, and as organized frameworks for solving problems [35]. Piaget used the concept of schemas to refer to a narrow range of abstract operations and which form content perspectives [36]. All the contents, principles, rules and procedures that students learn are organized into schemes that allow them to make sense of the world. Humans adopt a vast range of schemas, enabling us to make sense and place any new information or experiences into context. Once formed, the hierarchical schemas guide our information processing and behavior [37]. In computer programming students translate a program specification into programming language code, drawing heavily on abstraction skills and developed schemas in memory.

The practice of describing people's beliefs and actions in terms of mental schemas has been used extensively in cognitive psychology and cognitive science, for phenomena as diverse as how people solve brainteasers to how they troubleshoot steam boilers [38]. In the case of technology and organizations "individuals mental models tend to be oriented around established practices and norms, and may limit perception and understanding of an innovation" (p.23).

DISCUSSION

In the developed countries worldwide there has been a major increase in the number of adults returning to third level education in recent years. These adults are enrolling in courses varying from the social sciences to engineering disciplines. Many such adults enroll on computing courses and the prospect of studying programming can be overwhelming. This is especially the case in relation to Ireland whose government is pursuing an economic development strategy based on the knowledge society.

Developing learning strategies is very important not alone for the traditional student who enters higher education after finishing their second level education, but also for those students re-entering the education system after, or while, working in industry. As governments invest in knowledge economies and support life-long learning, structures and support systems to facilitate the up-skilling and professional development of the workforce at all levels is crucial and need to be develop within education. The findings presented in this paper highlight once again that the psychological needs of the individual should be recognized and supported within the higher education system. The results from the Computer Programming Anxiety Questionnaire re-emphasizes that education needs to be individualized, supported and ensure that student perceptions are met.

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