Self-Identified Capabilities and Experiences with Mathematics of Adults Who Have Taken a Developmental Algebra Course

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Abstract: Some were born to do math, some persevered past fearful environments, while others withdrew. In this qualitative study, adults describe life with algebra and the meaning they sought. For all, pedagogy was critical, either positively or negatively; and all found salvation in intervention.

They came from different backgrounds, different countries, and different schools, but all faced the same challenge – taking an algebra course at college. They were the five people who agreed to speak with me about their encounter with Algebra. For all of them, it was a stepping stone, a mandatory, though sometimes perceived as useless, stop on the way to something greater. One called it Elementary Algebra, some said College Algebra. Only one acknowledged it as "a remedial course." Developmental (or remedial) education is defined as "courses or services provided for the purpose of helping underprepared college students attain their academic goals" (Boroch et al., 2007, p. 82). Thus, introductory algebra courses are considered developmental. Many times students do not get credit for them, as they merely provide the knowledge base for the trigonometry course, which itself is the pre-requisite for college math and calculus courses (Small, 2006). Over 52% of the students enrolled in math courses are in developmental math (CBMS Survey, 1992). Of these, over 80% never progress beyond remediation (Viadero, 2009) making algebra courses the gatekeeper determining who achieves higher-level jobs (Moses & Cobb, 2001), full citizenship, or a higher education (Stinson, 2004).

Many adults find themselves in this developmental population as they return to school (AACC, 2011, Fast facts). Along with taking greater responsibility for their own learning, adults are looking for meaningful education that is geared towards problem-solving (Knowles, Holton, & Swanson, 1998). Those that are part of the digital generation – using technology as a natural part of life (Duderstadt, 1997) - prefer participation and experimentation instead of the "sequential, pyramid approach of the traditional university curriculum" (p. 80). With the requirement for providing interactive learning experiences (AMATYC, 2006), there are new opportunities and technologies available today. Yet failure and attrition rates in developmental courses continue to hover at over 50% (Small, 2006). With their varied needs and their desire to be more in control of their education, adult students should be partners in identifying the problem and crafting the solution.

The purpose of this study was therefore to attempt to uncover areas of intervention that can be addressed in a future algebra course. In particular, I considered that gaining an understanding of how students think about math and their ability to do math and exploring how they think experiences with math are contributing to their view of math today may be places to start in identifying areas of intervention. My research questions were:

1. How do at least three developmental algebra students view their capabilities in mathematics?
2. What do they consider to be stopping them from excelling in algebra?

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The Role of Experience in Attitudes Towards Mathematics

Prior research has sought to identify how students perceive math instruction (Weinstein, 2004); what functionality students remember from high school (Karsenty, 2002); success factors for women (Oswald & Harvey, 2003); and the success of media use in developmental courses (Star, Johnston, & Petty, 2008). Oswald and Harvey (2003), in particular, found a relationship between subjective experiences and how students perform in mathematics. Some students see no purpose in pursuing a subject that requires no thinking skills – merely "a process of memorizing and applying" (Erickson et al., 2008, p. 207). Others find themselves in the unappealing position of information receivers. Amidst claims that "school curriculum did not fit the customary ways of thinking and acting of working class students" (p. 207), even new technologies and opportunities may not appeal to the diverse adult population.

Effects of Pedagogy on Attitudes Towards Mathematics

Pedagogy can have positive and negative effects on students' learning and retention. When an authority figure in school creates an environment that violates a core need such as being able to see the world as a benevolent place, "an enduring sense of diminished control" (Chorpita & Barlow, 1998, p. 8) is established. These negative attitudes develop into math anxiety because of how mathematics is presented (Geist, 2010). Especially because math is considered an academic discipline with a focus on performance (Turner et al., 2002), there is a certain disregard for learner individuality and a hostile, competitive environment can be created that fails to resonate with learners' needs. The core need of making meaning of the world (Chorpita & Barlow, 1998) is also violated when students are taught formulas blindly with no understanding expected of how they will eventually be used. Adult learners, in particular, who are more proactive about their learning and seek education as solutions to daily life's problems (Betz, 1978) would be alienated by this environment as they would be unable to make meaning of the classroom world. Teachers' lack of interest and enthusiasm for teaching mathematics also affects students (Jackson & Leffingwell, 1999). Oswald and Harvey (2003) speak further of direct external discouragement and negative stereotypes that can be conveyed by teachers.

Method

Qualitative research was appropriate for a study like this as I was attempting to trace the conditions (Rubin & Rubin, 2005) that led to students' current perceptions of mathematics and algebra in particular. By means of interviews I hoped to explore what students perceived as barriers to their excelling in algebra and to identify areas of intervention that could be addressed in future algebra courses.

The Participants

Eight participants came by referral from friends and colleagues and had all experienced a remedial algebra course in college. One did not respond, and two indicated that they did not have time. Thus, I ended up with five participants from varied backgrounds and countries. Three were located in other states and towns thus the interviews were done using the computer so that they could be recorded. In keeping with the confidentiality promised the participants and after review and analysis of their responses, I have assigned a name to each that I feel reflects the participant's assessment of himself or herself.

The first interview was with Need-A-Voice. She is currently pursuing her Bachelor's in Business headed to an MBA. Born in Jamaica, she attended some high school in the US, but it was several years before she started college. She now works fulltime yet manages to take four to five courses each semester. Though math comes easy for her family, she feels she will never be "100% comfortable with it." She says that as far back as she can remember, "I do know that I

did not like math … my brain is not wired for math." Now, since working with a tutor, she says: "it is getting better … What is also helpful is to have someone, a live voice, speak through the material yeah. That is very helpful." I have known her for about a year and have been tutoring her for the past two months. Tutoring sessions were all done by phone or computer and were mostly review the night before an exam or answering questions along the way. Although my knowing her may have placed me in a position of power (Linhart, 2003) or colored her reflection, I found that she spoke quite calmly without hesitation. In addition the interview was on the computer with only an audio feed so there were no visual cues to distract her. Since she was so accessible she was the only one involved in member checking.

Need-A-Teacher was the second participant. She was born in Guyana but attended high school in the US. She started college many years after graduation, stopped then started back in earnest. So "it was kind of helpful taking the remedial class … before going on to the next class." According to her "I never liked math, never did" but the secret to topping her class is:

> I had a good teacher … I always tell people that if you don't like math, a lot of times it is because you don't have a good math teacher … I always say that, if you don't have a good math teacher then you are in trouble because math is not something that just comes naturally.

She worked fulltime through school, holds a Liberal Arts Associates, and is now pursuing a Bachelor's in Accounting.

My third interview was with Self-Teacher. She started college about 5 years after graduating high school, earned an Associates in Managerial Finance and is now pursuing a Bachelor's in Finance. It's been 9 years since her algebra classes but for her "it was just a repeat of high school so they were easy." She shared:

> The classes I took were self-paced. I did not have a teacher, I did it part online and by myself. I just did self-math. Didn't have a teacher, didn't have a problem with it. … Could contact the professor, but I never did.

She considers that "people's brains are just different. I just happened to be one of the good ones."

Science student, Need-To-See, at a four-year university, was my fourth interviewee. Fresh out of high school, she is pursuing a bachelor's in biology. She always loved math, even getting A's. Now, she misses the slower pace, longer lectures that explained every-thing and gave more examples, and says about the required time on the computer working homework with interactive tools: "I struggle learning math and reading all that information. I am more of a visual learner, I like seeing the instructor." Her grade level has dropped to borderline B to C.

The last interviewee was See-Whole-Problem. He is just starting college but could not complete the algebra course as he could not afford all the online practice materials needed. For him, he needs to "stay focused on the whole problem, not just the numbers" but he considers that math is "something I can do." I met him face-to-face at the place where he was volunteering. We sat at a concrete table outside and talked as he traced the outline of the geometric shapes of which he spoke and tapped the table deliberately for emphasis. He hopes to get a bachelor's in physical education so that he can teach.

As the interviewer, I fulfilled a desire of mine to hear the students' side of the algebra experience. I have been teaching online and ground-based developmental algebra courses for several years and am disturbed by the high failure rate. I have felt some responsibility lies with the student to make any effort necessary to understand and battle through the algebra haze. Yet mindful of my own subjectivity, I was able to empathize with Need-To-See as she spoke of a teacher who makes her feel she is holding up the class by asking questions during the limited

class time, with Need-A-Teacher as she spoke of professors who "may teach it [math] because they have a degree, but not specifically in math", and with Need-A-Voice as she spoke of the need for patience and full explanations. During each interview I monitored myself waiting for the participant to speak, asked for more specifics and simply followed along as they spoke. However my experience in the math classroom caused me to recognize some of the advice and methods being given by See-Whole-Problem as having been drummed into him over the years: "when you get the formula and … it comes to testing, you jot it down like real quick and you plug in the number and you know that you're right about the formula, the whole problem becomes real easy."

The Procedure

The research design used was a basic interpretive case study (Bogdan & Biklen, 2007) in which I interviewed participants then looked for the themes that emerged from their responses. The process began with the selection of the responsive interviewing model (Rubin & Rubin, 2005) tool because I felt a less formal environment would make participants more comfortable as they shared. The questions started out with "So how are you doing today?" and proceeded in the same open-ended vein to: "How do you consider that you use math outside of school" and "Sorry it was not a more memorable experience for you but tell me some more about that, how did it go?" Experiences were explored as to the format of the course; the environment for asking questions; the student-teacher, student-student and student-family relationships; and personal characteristics that contributed to success. Along the way, I reflected in my journal about possible anomalies and any changes needed in future interviews.

Each interview was taped and transcribed verbatim and then coded by reading through the transcript with no preconceived thought of what it would contain. Four clear themes emerged:

1. Attitude towards math such as self-concept, ability level and comfort level
2. Recognition of the need for intervention and how it was achieved
3. Keys to success / lack of success indicating the factors which contributed to poor performance or success
4. The role of pedagogy indicating factors in how the course was structured that contributed to poor performance or success from each interviewee's perspective.

Within each of these themes were several subcategories that reflected the mix of feelings and experiences involved. For example an overall attitude towards math emerged that was not always in line with the specific feeling towards the most recent course. A member check with Need-A-Voice indicated agreement with the themes I chose.

I then collected the comments into one file putting responses for each theme together, then synthesized a comprehensive set of subcategories, and tabulated responses in summary form. These tables are shown in Figure 1. In this way I could compare responses and identify thoughts that were not shared. I then proceeded to look for similarities / differences in experiences and if their commonality or lack thereof could be explained by theory. Finally I made recommendation of how issues raised can be addressed in future algebra courses or researched further.

Findings

Analysis of the themes portrayed some adults who, in line with the literature, desired to orchestrate their own learning, leaving repetition and memorization behind (Erickson et al., 2008), while surprisingly, the younger, digital generation who supposedly prefer participation

and experimentation (Duderstadt, 1997) were not so willing to let go of passive note-taking. Another surprising finding that emerged was the common reason attributed to retention issues.

Attitude toward Math

I started analysis by looking at the participants' attitude towards math overall and the latest algebra course in particular. Quite an alarming trend was seen. Need-A-Voice always felt that "math is not my favorite subject," but went from a general "my focus is to learn the rules" to "when I started this class I became afraid." At the root of this fear was an instructor:

> the pace picked up and there wasn't that care. It was literally you have, here are the formulas, go and learn these formulas and let's get going. And if you are like me who really are not comfortable with algebra, that was kind of the beginning of ugh this is not that good.

Need-To-See also experienced a downward attitude, from "I loved math back then, I did very, very good. I would always get A's" to "It is different now. I am comfortable but I think it is a lot of information for one semester. I don't like that I have to teach myself." When asked what was different about high school she indicated that

> I did better because my teacher was a really good teacher [laugh] I understood everything. I was in an environment where I was comfortable and I had no problem raising my hand and asking questions. I took a lot of notes. It was done at a pace that was good for me.

In this course, students got 2 hours of lecture time per week (even though the syllabus called for 3); then they had to spend 3 hours in the lab working through homework exercises. On the computer they could click to get explanations and suggestions for solving or they could request help from the Learning Assistant in the lab. But the

> Homework for the class does not really match the test. It's the same material but in the test they expect you to show your work but in the homework you don't have to. You don't have to graph certain things by hand [on the homework] so if you don't know how to do it [on the test] you get it wrong.

Once again the blame was laid at the teacher's door for not providing an environment conducive to consistency, explanations, examples, and questions.

Though being more willing to learn because she can see the benefit of algebra, Need-A-Teacher admitted that she never liked math. She admitted that

> [Before] I couldn't understand like how x and y would be applied in your life. What does this have to do with y'know someone who wants to be a doctor or lawyer or teacher, that's how I thought, who wants to know algebra? What was the reason or purpose for algebra? That was always my initial thought in math.

However, it was a teacher who made a positive difference for her and today she insists that after an encounter with a "good math teacher …I can see why it is being taught. But not all parts of the topics being taught apply to my life." As she went higher in math, she also saw the benefit of the earlier procedures.

Finally, Self-Teacher changed the one thing she felt needed changing: "the long lecture by teachers. But I changed that and take things online and I'm better at teaching myself." However, she found helpful the videos posted by a teacher giving lectures on the tough parts of the finance course. So maybe Need-A-Teacher is right that the teacher can make or break the experience. However, there are no general rules that apply to everyone: while Need-A-Voice could use more vocal support, Need-To-See has to see the instructor as she considers herself a visual learner.

The Need for Intervention and What Worked

All participants were willing to get help when they ran into problems. Two main interventions helped: (a) support from a tutor or the professor, and (b) increased relevance of the material that produced a mind change. For Need-A-Voice it translated to getting to "a place in my mind where once I understood perhaps not 100% but I thought a good, some, some, um, some understanding of what I was doing then my comfort level grew." She went on to say that "certainly the confidence I am now feeling thanks to that tutor, it has caused me to be more, it has just caused me to be more confident." Need-A-Teacher indicated that

> After we started to apply stuff like even stuff like percentage, how to calculate percentage in your head, you do that all the time, like calculate the tip, you do the math in your head, you don't need a calculator at all times. So it became interesting when you started to apply it to your daily life.

She too experienced a mind change:

> I think when you realize that the initial issue with math, a lot of people think they don't have to use it in their daily life and why do you need it. And I think when you realize and understand that you do need it in your daily life it does not matter what you do. If you want to progress in any other subject you still need math. So I think my realization of that is what helped me.

Review with a tutor helped Need-To-See while studying more helped See-Whole-Problem.

Keys to Success / Lack of Success

There were several subcategories here on which at least four participants agreed and at least two agreed on the rest. The keys that resonated most were: (a) mind change through understanding; (b) real-world application; (c) pedagogy that showed care, patience, support, comfortable environment; (d) more time to cover material; and (e) improved study habits. Showing up less frequently was the need for (a) consistency, (b) fewer topics covered in longer time, and (c) more active support from a tutor or learning assistant.

Though all participants felt that pedagogy was important, each needed a different aspect of it. Need-A-Voice wanted verbal review of prior steps as new ones were taught:

> You know almost like you are reminding somebody oh remember when we get to this part, this is what you do. You know, and then you go on. Instead of just jumping to the next step and the feeling is we should see what is needed, what you needed to do in order to get to that next step, and oh by the way, I am not going to go over that.

Need-A-Teacher felt that a good teacher was needed who had specialized in math. Also, she felt that the concepts should be taught starting from a younger age otherwise "if you don't start knowing multiplication and division and those basic things from young, you kind of, all this stuff that you are learning at an older age is compressed, so much information at a time, then math seems complicated."

Self-Teacher felt that different explanations were key as there are "Just different ways of learning for different people." Need-To-See wanted to see the instructor writing examples on the board so that she could take notes and "have [more] one-on-one time with the instructor." See-Whole-Problem felt that how the professor taught it made him ask questions so the teacher would review. He needed to stay focused on the whole problem, not just the numbers. For him, being able to see math in everything from the football field to the basketball court made it so much more important for him to understand and want to ask questions.

Four of the participants mentioned retention issues. Need-A-Voice and Need-To-See indicated that the memorization, rote style of learning that obviated understanding made it hard to retain information. Need-A-Teacher indicated that there was just too much to learn, and Self-Teacher was just prepared to use Google to find whatever she could not remember.

All participants earmarked the lack of relevance to their degrees or their current level of learning as a source of frustration. For Need-A-Voice,

> This is my third algebra class. I don't get the feeling that [relevance] is the focus for all of these classes I've taken, that's really not it. It's not you know, Being able to make a connection between it and business, not really. For me the majority of algebra for me is not reasoning, it is learning the rule and knowing when to apply it.

Having taken higher level math classes, Need-A-Teacher can finally see that algebra prepares you adequately for future math classes. She admitted that the realization of its relevance was the turning point for her. Using books that "had real world stuff in it so it showed you where you would use it so it all seemed relevant" worked really well for Self-Teacher. She still uses many of the concepts even though she has forgotten the names of the theorems. Need-To-See finds that "besides the whole interest and money thing I find everything else useless." See-Whole-Problem shows the extreme importance of making math relevant:

> I would say yes because the word problems don't just go with math, it could be with the dimension of a circle of a square or a rectangle, e.g. a basketball court is rectangle in shape so if you measure the side you would come up with the whole outer part of the rectangle. Like the width how long it is, 12, the other side would be the same, 12, because it's the sides of a rectangle [measuring off] so when you reading a word problem, from an athletic point of view, it relates to math.

The Role of Pedagogy

The experiences that were shared in this study mirror the positive and negative effects of pedagogy. Though none of the participants experienced direct discouragement nor negative stereotypes, there were characteristics of the classes themselves that contributed to fear leading to lack of comfort and confidence. This fear was felt by Need-A-Voice with a professor who would not take the time to explain and by Need-To-See who acknowledged the professor simply did not have enough time to explain everything thus expected all learner types to teach themselves using technology in the lab. Although the lab time may be working for some, there are some whose performance may be suffering. Need-A-Teacher noted that professors need to specialize in math if they will be teaching algebra while Self-Teacher found her own answers.

Implications

This study set out to find the answers to questions about self-identified capabilities and barriers stopping students from excelling in algebra. The answers, some surprising, are still disheartening in that with all the technological advances, the affective and even cognitive needs of the students are still not being met. Barriers centered around two main areas: (a) pedagogy or how the instructor structured the course format and classroom, including technology use; and (b) the need for real-world application of algebraic material. This is in keeping with the learning style of adults which do not seem to resonate with "authoritative teaching, examinations which preclude original thinking, [or] rigid pedagogical formulae" (Lindeman, 1961, p. 10). More research is also needed on how technology and learning styles interact. Not only should the average passing grade increase but students who did well should be maintaining their grades.

For my teaching, the key takeaway from this study is to provide a classroom that appeals to a variety of learners and does not assume that everyone likes a technocentric environment.

The need for talking through math anxiety and comfort issues has been reinforced as has the need to provide constant oral and visual support. Classroom materials must be consistent and, above all, relevant, to each degree program. As Orr (2004) called for the "redesign of education itself" (p. 3), so an intervention is needed for students, and the very pedagogy of algebra.

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Attitude toward Math	**Need-A-Voice**	**Need-A-Teacher**	**Self-Teacher**	**Need-to-See**	**See-Whole-Problem**
Overall feeling	Not favorite	Not always applicable	Easy	Comfortable but harder now	
Specific to class	Fear began, brain not wired	Remedial but helpful, interesting	Repeat from high school	Don’t like that I have to teach myself	Had no problem doing hw
Comfort level	Never will be 100%	More comfortable with more relevance	No problem with it	Comfortable but lot of info	
Self-concept of ability	Doesn’t come easy	Does not come naturally	Brain clicked	Loved it, would encourage myself	Something I can do
Hope for improvement	It is getting better	After started to apply			Have to ask questions
Longevity	Did not like math	Never liked math	Always in advanced math	Loved math back then (hs)	
Tutoring	Need live voice speaking thru	Really good professor – did not feel lost		Tutor review before test	
Mind / habit change	More confidence, comfort level went up, understanding increased	Relevance Increased interest			Studied more
Mind / habit change	Understanding leading to comfort Not try to make sense, just rules	Self-motivated, understanding its use	Understand logic behind math	Comfortable environment	Understand step-by-step nature

Attitude toward Math	Need-A-Voice	Need-A-Teacher	Self-Teacher	Need-to-See	See-Whole-Problem
Application	Relevance, Practical application	Apply what is taught, Relevance	Understand Why, real-world applications		Real-world application
Pedagogy	Care in teaching, more detail, reminders	Patient, good, specialize in math, supportive	Different explanations, Lectures only for tougher stuff	Visual learner, lecture-driven, open to questions, review time	Focus on whole problem not just numbers
Consistency	Alignment between lecture and homework			Better match bet practice and exam formats	
More time	More time to cover material	Start learning earlier	Self-paced	More lecture time, less lab	
Meeting times	Shorter, more often			Fewer topics, more time	
Support	Tutor, live voice			LAs, 1-1 with prof	Answer questions.
Retention Issues	Memorization not sufficient	A lot to retain	Be prepared to research	Lower as went thru this course	
Study habits	Lot of studying	Lot of studying	Self-teacher	Review with tutor	Study, study
Pedagogy – positive	Understanding	Patient	Self-taught	Repetition, Lots of examples, by hand	Open to questions, class size, lots of examples
Pedagogy – negative	Here are the formulas, Memorization			Environment not conducive to questions, More lecture needed	No access to online component
Support	Can't be self-taught, no office hours	Did not need to use office hours, but available	Full support, did not use.	Full support, but have to teach myself	Lots of support
Session length	Too long	6-hours, No credit		Too short	
Content	Too much	A lot		Too much	
Personal	Marooned	Self-motivated, but paid high price	Self-motivated	Visual learner	Need to ask questions

Figure 1. Summary of coding themes and sub-categories