Constructs of Integrated Multicultural Instructional Design for Undergraduate Mathematical Thinking Courses for Nonmathematics Majors

Irene M. Duranczyk and Jeanne L. Higbee
Department of Postsecondary Teaching and Learning
College of Education and Human Development
University of Minnesota

Abstract

This paper introduces a new inclusive theoretical model, integrated multicultural instructional design (IMID), and discusses its potential for application within undergraduate mathematical thinking courses for nonmathematics majors. The guiding principles of IMID build upon the constructs of multicultural education, ethnomathematics, and universal instructional design (UID), a model for inclusion of students with disabilities in higher education. The paper addresses how IMID is compatible with research and practices promoted by international and national mathematics organizations by maximizing equity, access, and success for all learners. The international goal of increased mathematical literacy necessary for all to achieve effective global citizenship and participation is addressed.

Introduction

The continuum of agrarian, industrial and post-industrial societies has a need for mathematics literacy to maximize productivity and social justice. Tertiary mathematics coursework is an integral part of a college degree in most countries of the world. It is incumbent for mathematics faculty to enhance the likelihood that all students will not only pass a required course for tertiary degree attainment, but also achieve a high level of mathematics literacy for effective global citizenship. Without universal mathematics literacy, equity and justice in our increasingly global society will be more difficult to achieve.

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We present a theoretical framework for re-visioning curricular design in undergraduate maths that promotes the advancement of mathematics literacy for all by integrating multicultural mathematics, ethnomathematics, and universal instructional design theory with the international guidelines for best practices and success in maths. Required maths courses for non-STEM (science, technology, engineering, or mathematics) majors are the primary focus of this chapter, although the design is applicable to all maths classrooms. Compulsory maths courses at university for students who are not majoring in maths or mathematics-based disciplines offer unique challenges for faculty and students—a need to develop a shared sense of need, purpose, engagement, and success, as well as a valuing of maths for gaining a greater understanding of the world (Alsina, 2001).

In recent decades much attention has been given to responding to changing student demographics in postsecondary education (Crissman Ishler, 2005; Gurria, 2009; Higbee, 2009) and to facilitating educational access for students from historically underserved populations throughout the world (David, in press; Ferrier & Heagney, 2008). Numerous research projects have established that student diversity enhances many aspects of the educational experience for *all* students (Gurin, Dey, Hurtado, & Gurin, 2002; Maruyama, Nirebim, Gudeman, & Marin, 2000; Pascarella, Palmer, Moye, & Pierson, 2001; Terenzini, Cabrera, Colbeck, Bjorklund, & Parent, 2001). In one study (Barron, Pieper, Lee, Nantharath, Higbee, & Schultz, 2007), students responded to the question, "How do you *personally* benefit from the diversity of the student body at [institution]?" The predominant theme that emerged from the analysis of the data was that students perceived that interactions with others can lead to being more open to different cultural perspectives. Several students from historically underrepresented populations also noted that they felt a greater sense of belonging because of the diversity of the students in their classes.

However, achieving a “critical mass” (Barron et al., pp. 38-39) is not enough. Too often institutions focus on what might be construed as a “numbers game”—recruiting and admitting an increasing proportion of “minority” students (e.g., students of color, students with disabilities, students who represent the first generation in their family to attend college)—without adequate concern for what happens to these students after they enroll. Institutions and the administrators, faculty, and staff who fulfill their educational missions need to look beyond the mere existence of student diversity and instead consider the many ways in which attitudes and behaviors shape how we as educators address this diversity in our curricula and programmes.

For purposes, “diversity” will be used to refer to the existence of diverse social identities, whether defined by race, ethnicity, culture, religion, spirituality, age, gender, sexual orientation, disability, social class, language, citizenship, or any other aspect of identity or combination thereof. Meanwhile, “multiculturalism” will refer to how we respond to diverse social identities: “If diversity is an empirical condition—the existence of multiple group identities in a society—multiculturalism names a particular posture towards this reality” (Miksch et al.,, 2003, pp. 5-6).

Ethnomathematics is

> the mathematics which is practised among identifiable cultural groups, such as national-tribal societies, labor groups, children of a certain age bracket, professional classes, and so on. Its identity depends largely on focuses of interest, on motivation, and on certain codes and jargons which do not belong to the realm of academic mathematics. (D’Ambrosio, 1985, p. 45)

Ethnomathematics researchers and practitioners have used cultural artifacts to advance student thinking and explorations of major mathematical concepts (D’Ambrosio, 1985; Powell & Frankenstein, 1997). Examples have included comparing and contrasting various indigenous numbers and numeration systems to reach a clearer understanding of our number system, exploring cultural designs and patterns in artifacts and cloths to enhance understanding of geometric concepts, examining the forms and purposes of historical architectural patterns worldwide to broaden our mathematical thinking of space, and engaging in cultural games of skill and chance to experience the universality of mathematics as a cultural expression (Ascher, 1991, 2002; Zaslavsky, 1973). Present-day explorations in ethnomathematics include using students' lived experiences, casting students in the role of researcher, and bridging academic mathematics with the hidden mathematics of everyday life (e.g., riding the bus, negotiating a freeway system, budgeting, time management, shopping, mental math activities, current events [Moses & Cobb, 2001]). For example, Duranczyk and Lee (2007) engaged students in a service-learning project building a house for Habitat for Humanity and related both mathematics and writing assignments to the project. Ethnomathematicians seek to capture the mathematical thinking and skills students use and relate them to academic mathematical concepts and skills necessary for individual, social, political, and economic progress (Duranczyk et al., 2004; Duranczyk & Lee (2007); Moses & Cobb (2001)). Multicultural mathematics educators and researchers have emphasized the importance of using and demonstrating the contributions of all cultures in the advancement of mathematical thinking (Atweh, Forgasz, & Nebres, 2001; English, 2002; Joseph, 2000; Rodriguez & Kitchen, 2009; Solomon, 2009; Staats, 2005). Here emphasis is on incorporating activities and examples representative of the students' cultural identities within the classroom and researching the effectiveness of those experiences.

The implementation of pedagogical models such as universal instructional design (UID; Goff & Higbee, 2008a, 2008b; Higbee & Goff, 2008; Silver, Bourke, & Strehorn, 1998), which was initially developed to widen participation among students with disabilities, can impact *how* we teach as well as *what* we teach and can benefit all students. As a model for multicultural postsecondary education, UID may serve as a starting point, but it does not fully capture the role that culture can play in the educational process (Hackman, 2008). Our purpose is to consider another model for transformative pedagogy—integrated multicultural instructional design (IMID) (Higbee & Goff, 2009; Higbee, Schultz, & Goff, in press)—and how it might be implemented in postsecondary maths classes and programmes of study.

It is important that the mathematical thinking courses that postsecondary students who are not mathematics majors take to complete their liberal education requirements are relevant, engaging, and rigorous. This student population presents one of the most difficult yet most rewarding teaching experiences for higher education faculty. There is often a mismatch between faculty and student experiences in understanding of and approaches to mathematics. In our increasingly technological and global community it is important for all world citizens to understand and apply mathematical thinking strategies while questioning and refining their worldview (Holton et.al, 2001). For example, how can citizens of the world without mathematical reasoning understand climate change? Our linked economies, workforce, goods, and natural resources demand an engaged citizenry with the ability to think quantitatively and understand complex problem solving.

IMID is a student-centered model developed to advantage students who were once marginalized in postsecondary education without disadvantaging students who enter the academy from a position of privilege or an understanding of the cultural capital needed to be successful. Students who are the first in their family to attend tertiary education may not have the practical information necessary for success (e.g., study skills, help-seeking behaviors, question posing, interface of practicing mathematical reasoning and skills with academic mathematics, study groups, understanding of mathematical terms), but if these activities and skills are built into the course work and students see the advantages of them for their progress, then marginalized students are supported and students who have utilized these skills and techniques are also supported. As Solomon (2009) reported,

> traditional [undergraduate] mathematics teaching and curricula have the effect of denying many learners access to high-status mathematics knowledge. In particular, it denies them access to meaning-making in mathematics perpetuating narrow epistemologies, marginalized identities and a corresponding lack of ownership. (p. 137)

If all students begin the study of functions by looking at natural events in their daily lives, identifying how they understand the relationship, rate of change, posing what ifs (i.e., interpolating and extrapolating) from data they have experienced, there is an opportunity for a level playing field irrespective of students' differences in academic language and skills. Promoting equity begins with acknowledging and building on students' lived experiences and incorporating their natural approaches to problem solving and interfaces this approach with more academic mathematics.

The next section will focus on understanding local as well as global challenges to incorporating students' lived experiences in the maths classroom and then introduce the guiding principles of the IMID theoretical model and its applications to mathematics literacy. Its purpose is to stimulate thinking about assumptions about the breadth and scope of mathematical thinking necessary for an interdependent global community and seeing mathematics as the cultural tool it was designed to be.

International Standards for Mathematics

A body of research and practice integrates ethnomathematics, UID, and multicultural mathematics into the compulsory education system and some compulsory-years teacher education programmes (Atweh et al., 2007). While Rodriguez and Kitchen (2002) have edited a

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collection of resources for preparing primary and secondary teachers for diverse classroom, the Holton et al. (2001) collection focuses on undergraduate mathematics. Researchers at higher education institutions have been studying the impact of these practices on widening the pool of students for science, technology, engineering, and mathematics (STEM) careers to enhance access and equity. The world stage is poised to move beyond implementing and assessing compulsory mathematics education to examine practices in higher education, particularly access and equity for nonmathematics majors who will need greater access to and success in mathematics literacy to function and contribute to the global community. This body of literature has formed the backbone of International Standards for Mathematics Education at the compulsory level and as criteria for study at the tertiary and university levels (Atweh et al.; Holton et al.; OECD, 2004, 2006, 2009; Rodriguez & Kitchen).

The International Mathematical Union (IMU) commissioned the International Congress on Mathematical Education (ICMI) in 1908 to promote international cooperation in mathematics and address the development of mathematics educational standards at all levels. ICMI has focused on compulsory maths, teacher education up to the tertiary level, and maths for STEM majors. Issues related to the mathematics education of tertiary students not in maths-based disciplines and courses are rarely represented in ICMI publications or conferences. In 1984 the Fifth International Congress on Mathematics Education in Australia birthed the International Study Group on Ethnomathematics (ISGEm), again with a focus on compulsory education and teacher education (Powell & Frankenstein, 1997). Recent interest in the internationalization of mathematics at the university level has been driven by globalization and the economics of higher education; this is quite different from the movement in compulsory education, which is driven more by the changing demographics of nations and the integration of indigenous, colonial, and recent immigrants into the same school systems that in many cases previously served only the children of privileged populations (Atweh et al., 2007; Holton et al., 2001).

In 2000 the world community through the Organisation for Economic Co-operation and Development (OECD; 2006) and its Directorate for Education established mathematics literacy goals for tertiary education and higher education. OECD started with 43 countries participating in establishing worldwide educational goals. The international education programme today involves 62 countries in efforts to establish international standardized assessment through the Programme for International Student Assessment (PISA) in tertiary mathematics education for 15-year-olds. The focus is mathematics literacy, defined as

> an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of the individual's life as a constructive, concerned and reflective citizen. (OECD, 2006, p. 72)

Member countries jointly developed the international mathematics literacy definition and guidelines for its assessment. There is agreement in the profession on these goals for tertiary education. The goals of ethnomathematics, multicultural mathematics and UID are consistent with these literacy goals. This definition moves us from an emphasis on specific mathematical content, techniques and components to the interface of mathematical ideas and literacy (e.g., concepts, ways of thinking, problem solving) with life.

Angel Gurria (2009), OECD Secretary-General, has challenged us to ensure equity among social groups, opening access to more fair, efficient, relevant, and effective higher education opportunities. Integrated multicultural instruction design promises to give direction for accomplishing this task with our international vision for enhanced mathematics literacy.

Throughout the worldwide mathematics community there is agreement that attitudinal barriers for both faculty and students are among the largest obstacles to raising mathematics literacy (Holton et al., 2001). The following quote is one such example; students

> think and believe that mathematics is for a select few. . . .mathematics faculty in NTCs [National Teachers Colleges in Uganda] invariably echoed the negative attitude and poor mathematics background by students as being the major setback to their mathematics attainment. (Ekol, 2008, p. 2)

This view limits our approach and ability to address the real issue, which is acknowledging that most students can learn mathematics if they see it as relevant, important, and necessary for their life and their community. Integrated multicultural instructional design provides a means for achieving this goal.

Integrated Multicultural Instructional Design

The IMID model is founded on a broad base of theoretical perspectives too numerous to detail within the context of this book chapter. Central to the model is constructivist theory, stemming from Dewey's (1936) belief in the critical role of experience as related to learning, and Vygotsky's (1978) view of learning as a social process. From Freire (1970) we learned that learning and cultural identity are inextricably intertwined, and the education can act as a means of oppression as well as a tool for liberation. More recent contributions come from theorists in multicultural education (Banks, 2008) and social justice education (Adams, Bell, & Griffin, 2007), with an emphasis on culturally responsive teaching (Gay, 2000). The IMID model is an outgrowth of previous work in multicultural awareness (Miksch et al., 2003) and universal instructional design (Silver, Bourke, & Strehorn, 1998; Higbee & Goff, 2008). Hackman (2008) proposed that UID alone is not enough, but holds significant promise when implemented in conjunction with critical multicultural education and social justice education approaches that recognize the importance of embedding cultural perspectives in learning. The development of the IMID model is a first step in operationalising this integration of theoretical perspectives. Integrated multicultural instructional design focuses on ensuring that institutions and the individuals affiliated with them make multiculturalism a way of life rather than an afterthought or an “add on.” A pyramid is the visual representation for the IMID model. The foundation of the pyramid is a community of postsecondary learners, scholars, and practitioners who value difference and express their commitment to diversity and multiculturalism pragmatically as well as theoretically, and who see themselves as part of a global community of engaged learners and educators. The students, administrators, faculty, and staff participating in this community create open pathways for communication to flow in all directions. Together they work to foster trust and mutual respect in order to create classrooms and other learning environments in which all students feel welcome and supported. Community members also understand that for true transformation to take place, their individual commitment must be matched by structural and systemic changes.

The four sides of the pyramid represent (a) “how we learn / how we teach”, (b) “what we learn / what we teach”, (c) “how we access academic support services / how we support learning”, and (d) “how we demonstrate what we have learned / how we assess learning.” For purposes of this discussion we will focus on the teacher’s responsibilities within this model; however, it is important to recognize the role that students play in contributing to their own learning as well, as presented in Figure 1. The following instructional guidelines build on previous projects and related research that has explored models for inclusion (Higbee & Goff, 2008, 2009; Higbee, Schultz, & Goff, in press; Miksch et al., 2003). *Figure 1:* Integrated

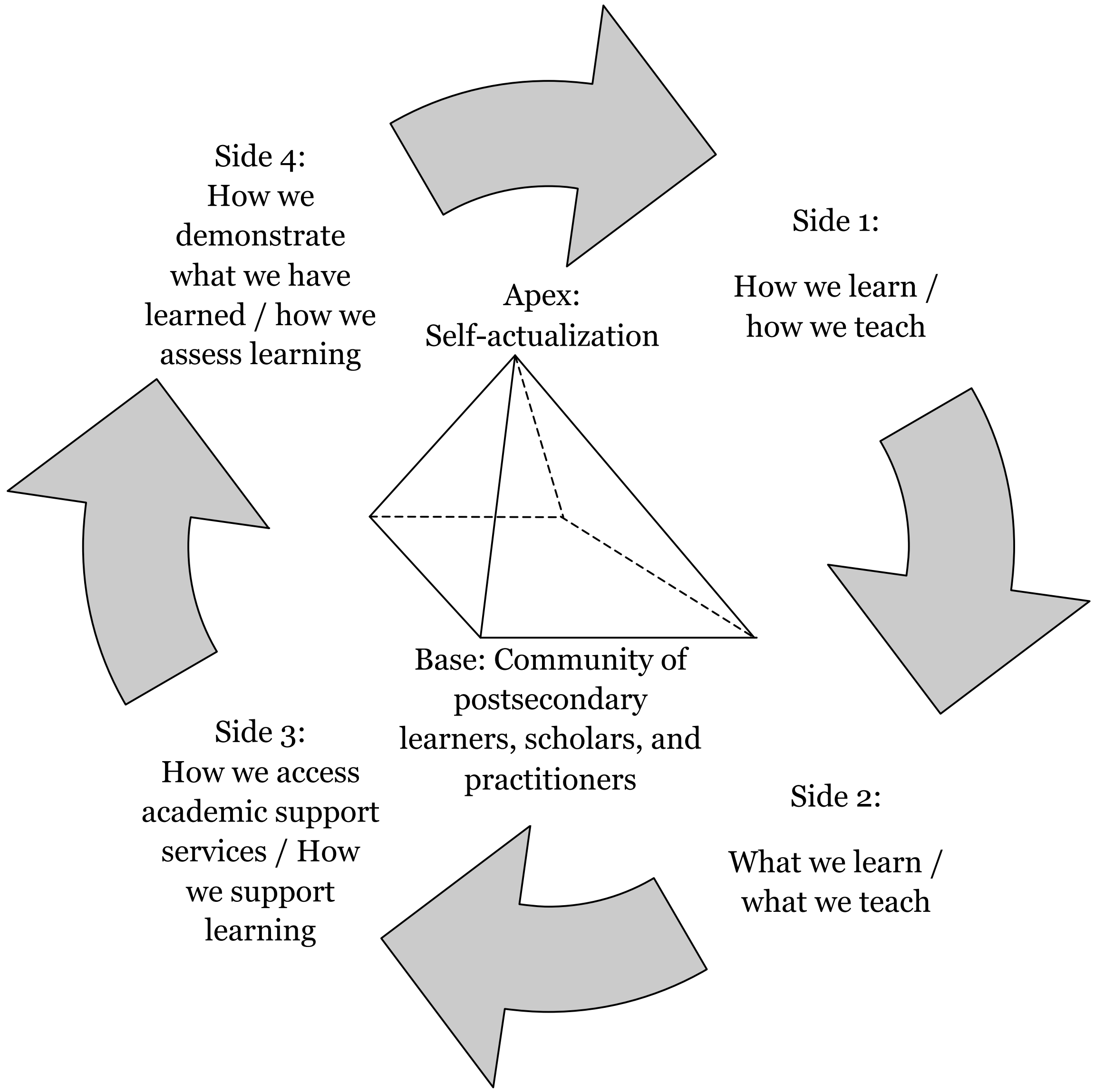

Figure 1: Integrated Multicultural Instructional Design

Guidelines related to how we teach include:

1. Promote understanding of how knowledge and personal experiences are shaped by the contexts (e.g., cultural, social, political, economic, historical) in which we live and work (Miksch

et al., 2003): It is important to consider these contexts because they also situate the application of mathematical principles.

2. Work collaboratively to construct knowledge: Through such approaches as inquiry-based learning, students collaborate among themselves as well as with faculty to create problem-solving strategies and draw conclusions.

3. Understand that learning is a complex process that involves many layers of reflection: Metacognitive strategies such as journaling or talking through the problem-solving process aloud assist students in understanding their own mathematical thinking.

4. Identify what skills must be developed in order to achieve mastery: From a universal instructional design perspective, this step is referred to as "determining essential course components" (Higbee & Goff, 2008). However, in considering essential components faculty sometimes limit their focus to content without considering student outcomes such as the ability to apply knowledge to the solution of real-life problems. Because mathematical skills build upon one another, it is critical to determine both the prerequisite skills for students entering a course as well as the skills students will need to develop in order to be successful in the course and in applying course concepts elsewhere.

5. Integrate skill development (e.g., critical thinking, problem solving, written and oral communication) with the acquisition of content knowledge (Higbee, Lundell, & Arendale, 2005): In addition to mathematical skills, faculty can facilitate the development of other life skills.

6. Establish and communicate clear expectations in terms of (a) learning objectives, (b) engagement in the teaching and learning process, and (c) evaluation measures for teaching and learning.

7. Use teaching methods that consider diverse learning styles, abilities, ways of knowing, and previous experience and background knowledge.

Guidelines for content—what we teach—include:

1. Determine what content mastery is essential for each class and for the programme or curriculum as a whole.

2. Establish class and programme objectives that reflect essential components and do not exclude students based on nonessential skills or prior knowledge.

3. Meet or exceed professional standards for excellence in content mastery within an environment of inclusion.

4. Integrate multicultural and global perspectives within course content.

5. Relate content to historical trends, current events, and future directions.

The focus of the third side of the pyramid—academic support—is developing natural supports for learning that enhance access, overcome previous inequities, and provide a scaffold for the learning process. Guiding principles for assessment, the fourth side of the pyramid, include creating multiple ways for students to demonstrate knowledge, ensuring the absence of bias in the assessment of student learning, and using formative as well as summative assessment measures. The IMID pyramid reflects Maslow's (1954) hierarchy of needs in that at its apex is self-actualization for all members of the educational community (see Figure 1). The next section provides strategies for implementing these guiding principles.

Implementation of IMID in the Classroom

When approaching the implementation of integrated multicultural instructional design in the classroom, the emphasis should be on total integration. When true integration is achieved it will be possible for students to develop identities of inclusion and achieve full participation rather than experiencing marginalization. If the class is viewed as a requirement to be checked off, both the instructor and the students will merely be going through the motions of teaching and learning. Sometimes going through the motions can spark an interest and common objective; but if efforts are made to find a mathematical connection first, then there is more likelihood that inquiry into the subject will produce meaningful insights or knowledge.

Although it is understood that the four sides of the IMID pyramid are interconnected, for purposes of this paper the ideas for implementation based on theoretical models and practical experiences with college students will be presented separately for each dimension. For greatest impact implementation plans should be developed based on course objectives and desired learning outcomes, which should in turn dictate course design. Many times students' first impressions of a class begin with the Web page, syllabus, and introductions on the first day. It is imperative that those initial experiences do not allow students to elect nonparticipation but rather give a consistent message of inviting the whole person and recognizing the value of each individual's unique social identity, lived experiences, and ways of knowing as contributions to the learning process. Creating opportunities for students to bond with one another is likewise time well spent. If inclusion is the goal, then attendance is not just a matter of absorbing mathematical literacy information, but a time to integrate one's worldview with the lens of how mathematics enhances the story of life or how life can be enhanced by the mathematical story, then the stage is set for inclusion. We cannot hope that these events happen; they must be explicitly incorporated into the class and made visible to the student. Creating a line in a syllabus or course document that invites diversity into the classroom is incomplete without clear actions in the classroom that make this goal visible and tangible. For example, before beginning a literacy topic on the use of numbers, the instructor can ask students to share with one another an experience they have had using data to support a personal decision. By exploring these situations, students will see how they have used data in their personal lives and the mathematical ideas uncovered can be used to begin the process of exploring academic mathematical language and concepts concerning data. Concepts based on the numbers can then be explored from the perspective of a context that relates to their personal experiences and acknowledges that the student has integral voice and authorship knowledge to contribute to the class.

How We Teach

Trends in international testing and global education indicate movement toward incorporating social constructivism within the maths curriculum, with more emphasis on group projects, project-based activities, small-group learning, and investigative approaches, and less emphasis on large lectures, complicated manipulations, and a linear approach to mathematical topics (Hillel, 2001; Reid & Petocz, 2007; Rodriguez & Kitchen, 2005). International tests such as PISA and *Trends in International Mathematics and Science Study* (TIMSS) have not only assessed mathematical content and mathematical thinking, but they have also collected information about students' attitudes regarding mathematics and their perceptions of the way mathematics is taught. Mathematics achievement appears to co-vary with attitudes, beliefs, and methods of instruction (Duranczyk & Opitz, 2005; Mullis, Martin, & Foy, 2008; OECD, 2006). Positive beliefs and attitudes about mathematics, high self-esteem, and an inquiry approach to learning have correlated with high performance on international achievement tests (OECD, 2004). At university level attention to attitudes and beliefs is often missing (Alsina, 2001). This is a key component for engaging students who are not mathematics majors, who are required to achieve a level of mathematical literacy for graduation. This is hard work for faculty and an area where additional training and sensitivities need to be developed.

There is no one right way of teaching in a diverse classroom. Applying sociocultural learning theory (Atweh, Forgasz, & Nebres, 2001; Duranczyk et al., 2004; Duranczyk & Lee, 2007; Moses & Cobb, 2001) enables faculty members to teach maths content modeling the process of knowledge-making, a method used by mathematicians and scientists. This student-centered approach begins with student understanding of the problem situation or event and advances from students' language and theories to intersections with formal mathematical language and presentations and ends with reflections on other possible applications or axiomatic knowledge. In the process of using a student-centered model the instructor establishes a learning environment that fosters trust and mutual respect in which all students feel welcome and supported. This work incorporates the goals of the international mathematics community and the goals of IMID. For example, a problem is posed. It could be as simple as "My cell phone contract is up. What would be the best service for me?" Or a more complex problem is posed, "There are residents in the city going hungry. There are empty lots available in the city for urban gardening. Would use of these lots eliminate hunger in the city?" In both cases students would need to problematize: (a) state what do I know; (b) decide what data/ information need to be collected to make this decision; (c) determine what assumptions are relevant to the situation; (d) examine the given the variables and how a model decision making process could be constructed; (e) if solving the problem, collect the data necessary; and (f) summarize conclusions.

What We Teach

In mathematics circles, the debate about what we teach continues. Are the essential components of a mathematics literacy programme discrete mathematics topics, algebra or calculus topics, statistics, logic, or is the essential component critical thinking with any one or combination of maths topics? What are we really teaching? Is it skills or algorithms, thinking or memorizing, literacy or a field of mathematics? What are students really learning? Is it how to pass a requisite class, how to meet the requirements for class completion, or how to see the beauty and relevance of mathematics for enhancing the quality of life and justice? One area of concern is that more attention needs to be paid explicitly to the contributions of all cultures to the field of mathematics and the impact of mathematics on framing social, economic, educational, historical, religious, family, and political positions (Curriculum Development Council & the Hong Kong Examinations and Assessment Authority, 2007; Duranczyk & Lee, 2007; Freire, 1973; Gutstein & Peterson, 2005; Moses & Cobb, 2001).

National and international standards have been developed in an attempt to create a seamless narrative of affective and cognitive goals for mathematics literacy. The following goals for Hong Kong provide an example of this alignment of standards:

> (a) develop **interest** in learning mathematics; (b) show **keenness** to participate in mathematical activities; (c) develop **sensitivity** towards the importance of mathematics in daily life; (d) show **confidence** in applying mathematical knowledge in daily life, by clarifying one's argument and challenging others' statements; (e) share ideas and experience and work **cooperatively** with others in accomplishing mathematical tasks/activities and solving mathematical problems; (f) understand and take up **responsibilities**; (g) be **open-minded**, willing to listen to others in the discussion of mathematical problems, respect others' opinions, and value and appreciate others' contributions; (h) **think independently** in solving mathematical problems; (i) be **persistent** in solving mathematical problems; and (j) **appreciate** the precise, aesthetic and cultural aspects of mathematics and the role of mathematics in human affairs. (Curriculum Development Council and the Hong Kong Examinations and Assessment Authority, 2007)

What content can lead us to achieve these goals for all students at the university level? Mathematics classes for the non-major can focus on interesting discrete mathematics topics such as: (a) voting and apportionment, (b) logic, (c) statistics, (d) probability and chance, (e) numeration and mathematical systems, and (f) the art of problem solving. Each of these topics lend themselves to contemporary and important global issues—chances to explore the numbers behind food, agriculture, banking, the environment, natural resources, equity, nation building, war, poverty, greed, and so on. Understanding the numbers behind the scene of our world problems and successes can model problem solving and integrated mathematical thinking and skills. Students can use their cultural capital while interfacing with academic mathematics. Through the mathematical analysis of contemporary problems, multicultural perspectives can be integrated into all aspects of the delivery of mathematics. In 1977 Freudenthal developed Realistic Mathematics, an approach for teaching mathematics in context that is used not only in the Netherlands but around the world and in applications with adults at the tertiary level (van der Kooij, 2001). Students are presented with meaningful, open-ended problems related and relevant to their experiences and these form the key resources for learning. The mathematics of the day arises by the process of mathematization. Academic mathematical tools and understanding are derived from the context-linked solutions generated by the students. Analysis of student models leads to higher levels of mathematical thinking.

If we consider seriously the essential components of a mathematical thinking class or a one-time maths class for non-majors, it may be approached similarly to an introductory science course, with a focus on questions such as, “What is the work of mathematizing?” “How can mathematics inform our life view?” “How can our life view inform mathematics?” “How can we increase the likelihood that students will achieve ‘sense making’ in the learning of mathematics that will enable them to participate actively in ‘doing mathematics’?” (Holton et al., 2001; Rodriquez & Kitchen, 2005). It is not difficult to imagine multicultural content embedded in how we address these questions.

How We Support Learning

How we support learning is a facet of IMID that generally is not addressed in sociocultural learning theory or within the standards for mathematics, but is an area that has usually been addressed in equity-based initiatives. Sanford (1966, 1968) introduced the notion that good teaching involves achieving a delicate balance between challenge and support. Mathematical content is challenging enough, and many postsecondary students are coping with previous negative learning experiences in compulsory maths classes. It is the responsibility of the instructor to provide and suggest supports to facilitate learning and assist students in overcoming negative attitudes about maths. In addition, other institutional resources, such as campus learning centres, can provide supplemental supports.

Higbee and Thomas (1998, 1999; Thomas & Higbee, 1996, 2000, 2001) collaborated over a period of years to explore barriers to learning maths and create supports to overcome those barriers in a series of developmental education algebra classes that was required for students who did not attain sufficient placement test scores to begin the university-level maths sequence. Some of the successful classroom strategies were (a) assessing student learning styles at the beginning of the term and exploring how students could use different learning strategies depending upon their preferred ways of knowing; (b) creating problem sets that reflected real-life uses for mathematics; (c) introducing culturally-relevant daily brain teasers that opened students' minds to the notion that doing maths can be fun; (d) providing a wide variety of manipulatives for students who learn best through experimentation or physical movement; (e) encouraging students to work collaboratively, but not requiring this of students who learned best working alone—particularly adult learners who wanted to learn at their own pace in their own way; (f) broadcasting daily telecasts of class sessions on public access television, which could then be recorded for later review; (g) providing extensive feedback on homework assignments; (h) presenting research results that established a significant relationship between attendance in class and final class grade; (i) discussing how mathematics is used in professions related to the students' academic majors; and (j) introducing relaxation exercises and test-taking strategies specific to maths tests. Students learned that there was not necessarily "one correct way" to solve complex mathematical problems and that sometimes intuition—or thinking about what makes sense—can be helpful in the problem-solving process. Meanwhile, the institution's learning centre also provided individual and small-group tutoring specific to the course and computer-generated, self-scoring practice tests, as well as test anxiety counseling specific to maths tests. Thomas and Higbee (1996) discovered that these strategies enabled students not only to be successful in the institution's lowest-level college algebra class, but also to outperform students with much stronger secondary school academic records in subsequent university-level maths course work.

How We Assess Learning

Up to the tertiary level international guidelines for assessment of learning mathematics are fairly well defined and in alignment with "what we teach"—the core skills and concepts, connections between these core skills and concepts, and finally application of these core skills and concepts that extends knowledge and understanding (OECD, 2004, 2006). At the higher education level assessment practices vary considerably (Huston, 2001). Too often examinations are "high stakes" situations where one false step can have a devastating impact on a student's grade or future opportunities. In keeping with the IMID model, assessment practices that encourage deep learning for all, create opportunities for students to achieve and demonstrate their learning in multiple ways, acknowledge that the unique timing of student learning may not correspond with the syllabus, and use assessment tools not to judge or rank students but to create awareness of students' strengths and areas for improvement ideally would be integrated into every class session. Assessment tools and techniques that model what one values as a teacher and learner will transform practice. The following sections discuss some transformative practices that have been used in higher education that promise to create a more level playing field for all students.

Group activities and projects

Group activities and projects more realistically model how mathematical skills are used in the real world and thereby are a natural way to assess mathematics literacy. Designing these activities and projects based on students' experiences and interests will create opportunities for students to explore culturally-sensitive topics and issues and maximize student engagement. Duranczyk and Lee (2007) Found that whether using mathematical reasoning skills at a Habitat for Humanity building site, to revisit our understanding of a natural disaster such as Hurricane Katrina in 2002, or for identifying a site for new public housing, students in small groups grew in mathematical reasoning and skills while grappling with real issues. The Duranczyk and Lee study showed gains for all students.

Tests as first drafts

Maths tests or assessments can be viewed as first drafts, a strategy commonly used in composition and writing disciplines (Duranczyk & Lee, 2007). In real world situations there are very few timed assessments of knowledge and skills. Tests as single, timed opportunities for demonstrating knowledge and skills limit what the instructor measures and disadvantage some students. Huston (2001) stated,

> Learning mathematics for the principal purpose of passing examinations often leads to surface learning, to memory learning alone, to learning that can only see small parts and

> not the whole of a subject, to learning wherein many of the skills and much of the knowledge required to be a working mathematician are overlooked. . . . And it seems a pity to leave out the possibilities for deep learning of the subject, that is, learning which is consolidated, learning which will be retained because it connects with previous learning, learning which develops curiosity and a thirst for more, learning which is demonstrably useful in working life. (p. 408)

Using a test as a first draft with second draft possibilities through in-class work, at home revisions, and conference sessions to explore interactively the concepts and skills are all ways to extend students' opportunities to demonstrate skill and knowledge development. These opportunities also extend the possibility for deep learning of mathematics literacy skills.

Scaffolding activities and projects

Most work that is done in the real world is done in stages with feedback, modifications, and then working towards a final project, a step-by-step process known as scaffolding. Students who might feel overwhelmed by larger assignments learn to break these assignments down into smaller, more manageable increments. Through scaffolding major activities and projects, students are afforded multiple opportunities to receive feedback, make corrections, and proceed with confidence toward a final outcome. Grading of such work can also be done incrementally so as not to add to anxiety and frustration along the way.

Real world applications and activities

The use of service learning and projects based on real-world problems and issues can advance the integration of IMID in mathematics. Doing mathematics that matters can add to student engagement, particularly for student populations that struggle to see the value of mathematics in their lives. Many opportunities can be created to interface with community projects (Duranczyk & Lee, 2007) that will allow students to apply particular mathematical skills and knowledge to real-world applications. When exploring statistics, creating community surveys and collecting real data on real interests can add to the value of the experience and deepen students' appreciation for mathematical concepts.

End of semester student showcase and portfolios

Finally, a summative evaluation of the semester's progress is another way to evaluate students' accomplishment in a holistic manner. Presentation showcases and student portfolios allow all students to reflect on their learning and accomplishments while packaging them developmentally for the instructor's review.

One important factor when implementing IMID is to create an assessment plan that matters and that models faculty and student values and commitments to multicultural learning and teaching. If interaction among and between faculty and students is demonstrably valued, then planning and arranging individual and small group conferences and presentations that are part of the assessment and grading process demonstrates that value. Grading office visits equivalent to a "quiz" if they are office visits with a particular agenda (returning of tests, major papers, major group projects) also demonstrates that value.

Lastly, there is the opportunity in a service course or a course for nonmaths majors to allow students to develop some of their own course goals and how they would prefer to be evaluated. It is important to be clear on which goals are negotiable and which are not. Assessment procedures can and would benefit from being a process of negotiation, particularly when our goal is increasing mathematics literacy for all students.

Next Steps

Although much progress has been made in the compulsory years for integrating access and equity for all in the maths classroom and parallel strides have been made in the preparation of compulsory-education-level teachers, these benefits have not been afforded to higher education mathematics curricula and classrooms (Solomon, 2009). Considering the four dimensions to access and equity: how we teach, what we teach, how we support learning, and we assess learning within maths, maths-based or maths literacy curricula and classrooms is our task for further research and wider implementation. The following practices will move us in the direction of greater world mathematics literacy.

1. Create a community of scholars across the globe to share ideas and resources, and do classroom-based research related to mathematics literacy for students not majoring in mathematics.

2. Advocate for and create opportunities for encouraging and rewarding mathematics professionals who specialize in working with mathematical thinking courses at the tertiary and university levels.

3. Review and replicate research conducted at the tertiary level.

4. Explore both cognitive and affective factors that impact success in maths literacy courses at the college level.

5. Create opportunities for interaction among the ethnomathematics, UID, and multicultural mathematics communities of scholars and those who specialize in mathematics literacy at the undergraduate level.

Undergraduate mathematics literacy curricula are not adequately studied or valued in our world community. We hope this exploration of the implementation of integrated multicultural instructional design in mathematics literacy endeavors will prompt further discussion and research to advance mathematics education at the postsecondary level to ensure access and success for students who have been marginalized in the past. Mathematics literacy is a worldwide imperative if we are to maximize productivity and promote social justice.

References

Adams, M., Bell, L. A., & Griffin, P. (2007). *Teaching for diversity and social justice* (2nd ed.). New York: Routledge, Taylor Francis Group.

Alsina, C. (2001). Why the professor must be a stimulating teacher. In D. Holton, M. Artigue, U. Kirchgräber, J. Hillel, M. Niss, & A. Schoenfeld (Eds.). (2001). *The teaching and learning of mathematics at university level: An ICMI study*. NewYork: Kluwer Academic Publishers.

Ascher, M. (1991). *Ethnomathematics: A multicultural view of mathematical ideas.* Belmont, CA: Brooks/Cole.

Ascher, M. (2002). *Mathematics elsewhere: An exploration of ideas across cultures.* Princeton, NJ: Princeton University Press.

Atweh, B., Calabrese Barton, A., Borba, M., Gough, N., Keitel, C., Vistro-Yu, C., & Vithal, R. (Eds.). (2007). *Interantionalisation and globalization in mathematics and science education.* Dordrecht, Netherlands: Springer.

Atweh, B., Forgasz, H., & Nebres, B. (Eds.). (2001). *Sociocultural research on mathematics education: An international perspective.* Mahwah, NJ: Lawrence Erlbaum Associates.

Banks, J. A. (2008). *An introduction to multicultural education* (4th ed.). Boston: Pearson.
Barron, R., Pieper, J., Lee, T., Nantharath, P., Higbee, J. L., & Schultz, J. (2007). Diversity and the postsecondary experience: Students give voice to their perspectives. In J. L. Higbee, D. B. Lundell, & I. M. Duranczyk (Eds.), *Diversity and the postsecondary experience* (pp. 37-47). Minneapolis: University of Minnesota, Center for Research on Developmental Education and Urban Literacy. Retrieved June 30, 2009, from http://www.cehd.umn.edu/CRDEUL/docs/monograph/Diversity.pdf

Crissman Ishler, J. L. (2005). Today's first-year students. In M. L. Upcraft, J. N. Gardner, B. O. Barefoot, & Associates, *Challenging and supporting the first year-student: A handbook for improving the first year of college* (pp. 15-26). San Francisco: Jossey-Bass.
Curriculum Development Council & the Hong Kong Examinations and Assessment Authority. (2007). *Mathematics: Curriculum and assessment*. Retrieved July 2, 2009, from http://www.edb.gov.hk/FileManager/EN/Content_5999/math_final_e.pdf

David, M. E. (Ed.). (in press). *Improving learning by widening participation in higher education.* London, UK: Routledge/Taylor Francis Group.

D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of mathematics. *For the Learning of Mathematics, 5*(1), 41-48.

Dewey, J. (1936). *Democracy in education.* New York: Macmillan.

Duranczyk, I. M., & Lee, A. (2007). Process pedagogy, engaging mathematics. *Academic Exchange Quarterly, 11*(2), 31-35.

Duranczyk, I. M., & Opitz, D. L. (2005). Reaching for the standards, embracing diversity: Students' perceptions of the mathematics program. In J. L. Higbee, D. B. Lundell, & D. R. Arendale (Eds.), *The General College vision: Integrating intellectual growth, multicultural perspectives, and student development* (pp. 479-517). Minneapolis: University of Minnesota, General College, Center for Research on Developmental Education and Urban Literacy. Retrieved July 22, 2009, from http://www.cehd.umn.edu/CRDEUL/pdf/TheGCVision/section6.pdf

Duranczyk, I. M., Staats, S., Moore, R., Hatch, J., Jensen, M., & Somdahl, C. (2004). Developmental mathematics explored through a sociocultural lens. In I. M. Duranczyk, J. L. Higbee, & D. B. Lundell (Eds.), *Best practices for access and retention in higher education* (pp. 43-53). Minneapolis: University of Minnesota, General College, Center for Research on Developmental Education and Urban Literacy. Retrieved July 22, 2009, from http://www.cehd.umn.edu/CRDEUL/pdf/monograph/5-a.pdf

Ekol, G. (2008, July). *Policy changes and their impact on non-university mathematics.* Paper presented at the 11th International Congress on Mathematics Education in Mexico. Retrieved July 3, 2009, from http://dg.icme11.org/document/get/424

English, L. D. (Ed.) (2002). *Handbook of international research in mathematics education.* Mahwah, NJ: Lawrence Erlbaum Associates.

Ferrier, F., & Heagney, M. (Eds.). (2008). *Higher education in diverse communities: Global perspectives, local initiatives.* London, UK: European Access Network and Higher Education Authority of Ireland, in cooperation with Masaryk University Press.

Freire, P. (1970). *Pedagogy of the oppressed.* New York: Continuum.

Freire, P. (1973). *Education for critical consciousness.* (M. B. Ramos, L. Bigwood, & M. Marshall, Trans.). New York: The Seabury Press. (Original work published 1969)

Gay, G. (2000). *Culturally responsive teaching: Theory, research, and practice.* New York: Teachers College Press.

Goff, E., & Higbee, J. L. (2008a). *Pedagogy and student services for institutional transformation (PASS IT) implementation guidebook for faculty and instructional staff.* Minneapolis: University of Minnesota. Retrieved June 30, 2009, from http://www.cehd.umn.edu/passit/docs/guidebook%202.pdf

Goff, E., & Higbee, J. L. (2008b). *Pedagogy and student services for institutional transformation (PASS IT) implementation guidebook for student development and learning support.* Minneapolis: University of Minnesota. Retrieved June 30, 2009, from http://www.cehd.umn.edu/passit/docs/guidebook%201.pdf

Gurin, P., Dey, E. L., Hurtado, S., & Gurin, G. (2002). Diversity and higher education: Theory and impact on student outcomes. *Harvard Educational Review, 72*(3), 330-366.

Gurria, A. (2009, July). *The new dynamics of higher education and research for societal change and development.* Introductory remarks at the UNESCO World Conference on Higher Education, Paris, France. Retrieved July 3, 2009, from http://www.oecd.org/documentprint/0,3455,en_2649_39263238_43264400_1_1_1_1,00.html

Gutstein, E., & Peterson, B. (2005) *Rethinking mathematics: Teaching social justice by the numbers.* Milwaukee, WI: Rethinking Schools, Ltd.

Hackman, H. W. (2008). Broadening the pathway to academic success: The critical intersection of social justice education, critical multicultural education, and universal instructional design. In J. L. Higbee & E. Goff (Eds.), *Pedagogy and student services for institutional transformation: Implementing universal design in higher education* (pp. 25-48). Minneapolis: University of Minnesota, Center for Research on Developmental Education and Urban Literacy. Retrieved June 30, 2009, from http://www.cehd.umn.edu/passit/docs/PASS-IT-Book.pdf

Higbee, J. L. (2009). Student diversity. In R. Flippo & D. Caverly (Eds.), *Handbook of college reading and study strategies research* (2nd ed.; pp. 67-94). New York: Routledge, Taylor & Francis Group.

Higbee, J. L., & Goff, E. (2008). *Pedagogy and student services for institutional transformation: Implementing universal design in higher education*. Minneapolis: University of Minnesota, Center for Research on Developmental Education and Urban Literacy. Retrieved June 30, 2009, from http://www.cehd.umn.edu/passit/docs/PASS-IT-Book.pdf

Higbee, J. L., & Goff, E. (2009). *Promoting inclusion and retention through integrated multicultural instructional design.* Unpublished manuscript, University of Minnesota-Twin Cities.

Higbee, J. L., Lundell, D. B., & Arendale, D. R. (Eds.). (2005). *The General College vision: Integrating intellectual growth, multicultural perspectives, and student development.* Minneapolis: University of Minnesota, General College, Center for Research on Developmental Education and Urban Literacy. Retrieved June 30, 2009, from http://www.cehd.umn.edu/CRDEUL/books-thegcvision.html

Higbee, J. L., Schultz, J. L., & Goff, E. (in press). The pedagogy of inclusion: Integrated multicultural instructional design. *Journal of College Reading and Learning.*

Higbee, J. L., & Thomas, P. V. (1998). Daily brain teasers: Promoting collaboration, persistence, and critical and creative thinking. *Academic Exchange Quarterly, 2*(4), 20-23.

Higbee, J. L., & Thomas, P. V. (1999). Affective and cognitive factors related to mathematics achievement. *Journal of Developmental Education, 23*(1), 8-10, 12, 14, 16, 32.

Hillel, J. (2001). Trends in curriculum. In D. Holton, M. Artigue, U. Kirchgräber, J. Hillel, M. Niss, & A. Schoenfeld (Eds.), *The teaching and learning of mathematics at university level: An ICMI study* (pp. 59-69). NewYork: Kluwer Academic Publishers.

Holton, D., Artigue, M., Kirchgräber, U., Hillel, J, Niss, M., & Schoenfeld, A. (Eds.). (2001). *The teaching and learning of mathematics at university level: An ICMI study*. NewYork: Kluwer Academic Publishers.

Huston, K. (2001). Assessing undergraduate mathematics students. In D. Holton, M. Artigue, U. Kirchgräber, J. Hillel, M. Niss, & A. Schoenfeld, (Eds.), *The teaching and learning of mathematics at university level: An ICMI study* (pp. 407-422). NewYork: Kluwer Academic Publishers.

Joseph, G. G. (2000). *The crest of the peacock: Non-European roots of mathematics.* Princeton, NJ: Princeton University Press.

Maruyama, G., Nirebim, J. F., Gudeman, R. H., & Marin, P. (2000). *Does diversity make a difference? Three research studies on diversity in college classrooms.* Washington, DC: American Council on Education & American Association of University Professors.

Maslow, A. (1954). *Motivation and personality*. New York: Harper.

Miksch, K. L., Higbee, J. L., Jehangir, R. R., Lundell, D. B., Bruch, P. L., Siaka, K., & Dotson, M. V. (2003). *Multicultural awareness project for institutional transformation: MAP IT.* Minneapolis: University of Minnesota, General College, Multicultural Concerns Committee and Center for Research on Developmental Education and Urban Literacy. Retrieved June 30, 2009, from http://www.cehd.umn.edu/CRDEUL/pdf/map_it.pdf

Moses, R. P., & Cobb, C. E. (2001). *Radical equations: Math literacy and civil rights.* Boston: Beacon Press.

Mullis, I. V. S., Martin, M. O., & Foy, P. (2008). *TIMMS 2007 international mathematics report: Findings from IEA's trends in international mathematics and science study at the fourth and eighth grades.* Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Organisation for Economic Co-operation and Development (OECD). (2004). *Learning for tomorrow's world: First results from PISA 2003.* Retrieved July 2, 2009, from http://www.oecd.org/dataoecd/1/60/34002216.pdf

OECD. (2006). *Assessing scientific, reading, and mathematical literacy: A framework for PISA 2006.* Retrieved July 2, 2009, from http://www.oecd.org/document/32/0,3343,en_2649_39263231_37468320_1_1_1_100.html

OECD. (2009). Thematic review of tertiary education. Retrieved July 3, 2009, from http://www.oecd.org/document/9/0,3343, en_2649_39263238_35564105_1_1_1_1,00.html

Pascarella, E. T., Palmer, B., Moye, M., & Pierson, C. (2001). Do diversity experiences influence the development of critical thinking? *Journal of College Student Development, 42,* 257-271.

Powell, A. B., & Frankenstein, M. (Eds.). (1997). *Ethnomathematics: Challenging Eurocentrism in mathematics education.* Albany, NY: State University of New York.

Reid, A. & Petocz, P. (2007). Internationalisation as an orientation for learning and teaching in mathematics. In B. Atweh, A. Calabrese Barton, M. Borba, N. Gough, C. Keitel, C. Vistro-Yu, & R. Vithal (Eds.), *Interantionalisation and globalization in mathematics and science education* (pp. 247-267). Dordrecht, Netherlands: Springer.

Rodriguez, A. J., & Kitchen, R. S. (Eds.) (2005). *Preparing Mathematics and science teachers for diverse classrooms: Promising strategies for transformative pedagogy.* Mahwah, NJ: Lawrence Erlbaum Associates.

Sanford, N. (1966). *Self and society: Social change and individual development.* New York: Atherton.

Sanford, N. (1968). *Where colleges fail: A study of student as person.* San Francisco: Jossey-Bass.

Silver, P., Bourke, A., & Strehorn, K. C. (1998). Universal instructional design in higher education: An approach for inclusion. *Equity and Excellence in Education*, *31*(2), 47-51.

Solomon, Y. (2009). *Mathematical literacy: Developing identities of inclusion*. NewYork: Routledge.

Staats, S. K. (2005). Multicultural mathematics: A social issues perspective in lesson planning. In J. L. Higbee, D. B. Lundell & D. R. Arendale (Eds.), *The General College vision: Integrating intellectual growth, multicultural perspectives, and student development.* (pp. 185-199). Minneapolis: University of Minnesota, General College, Center for Research on Developmental Education and Urban Literacy. Retrieved July 22, 2009, from http://www.cehd.umn.edu/CRDEUL/pdf/TheGCVision/section2.pdf

Terenzini, P. T., Cabrera, A. F., Colbeck, C. L., Bjorklund, S. A., & Parent, J. M. (2001). Racial and ethnic diversity in the classroom: Does it promote student learning? *Journal of Higher Education, 72,* 509-531.

Thomas, P. V., & Higbee, J. L. (1996). Enhancing mathematics achievement through collaborative problem solving. *The Learning Assistance Review, 1*(1), 38-46.

Thomas, P. V., & Higbee, J. L. (2000). The relationship between involvement and success in developmental algebra. *Journal of College Reading and Learning, 30*(2), 222-232.

Thomas, P. V., & Higbee, J. L. (2001). Teaching mathematics on television: Perks and pitfalls. In L.S. Hagedorn (Ed.), *Sound instruction: Ready to use classroom practice* (pp. 67-70). Chattanooga, TN: Rapid Intellect.

van der Kooij, Henk. (2001). Mathematics and key skills for the workplace. In M. van

Groenestijn (Ed.), *Adults Learning Maths Newsletter*. Retrieved on July 3, 2009, from http://www.alm-online.org/Newsletters/News13.pdf

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Zaslavsky, C. (1973). *Africa counts: Number and patterns in African culture.* Boston: Prindle, Weber, and Schmidt.