spring 2011

volume 75 number 2

THE ENGINEERING DESIGN GRAPHICS

Journal

ISSN: 1949-9167

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Editorial Board, Advisory Board, and Review Board

Online Distribution
The online EDGJ is a reality as a result of support provided by East Carolina University; Biwu Yang, Research & Development, ECU Academic Outreach; Blake Smith, ECU Academic Outreach; and Cody Skidmore, Duke University Help Desk Specialist and the Journal's Web Production Manager.

Engineering Design Graphics Journal (EDGJ)
Spring 2011, Vol. 75, No. 2
http://www.edgj.org

ISSN: 1949-9167

Message from the Chair

Timothy Sexton
Ohio University

If you are like me, at the end of the school year you ask yourself did I give my students my very best or were there times when I was on automatic pilot. What is it that makes me do my very best? One major reason is involvement in our Engineering Design Graphics Division. Inspiration is easy; in fact it only takes one thing: one interesting paper; one vendor showing off the latest software, textbook, or gadget; one unique idea about better teaching; one member showing his or her enthusiasm about their presentation; or the excitement in the eyes of a new member.

As I was perusing through past journals one article caught my eye and I had to stop and read it. Our journal provides continuity and intellectual stimulation. Intellectual stimulation is a great reason for belonging to EDGD but what are some other reasons for belonging to EDGD. The following are reasons why I'm glad to be a member: our vendors keep us on the cutting edge; there is security knowing there is always someone that can help you answer a graphics problem; our meetings are fun with lots of conviviality, we get to travel to exotic places like Houghton MI; EDGD provides us with an avenue to promotion and tenure; it's great to see how other institutions teach graphics; EDGD has awards for great papers, presentations, and for service to the division; one of the most exciting highlights of one's career is hosting a midyear meeting; and finally when you want to discuss the latest graphics technology your audience doesn't find you boring or strange.

Our division cannot continue to be successful without the help of its members. Start out small by volunteering to moderate a technical paper session or volunteer to be on a committee. Take the time to recruit new members. Since our EDG journal provides continuity to our division from year to year support it by contributing papers and encourage others to submit papers. Run for a directorship. The director of membership recruits new members, the director of publications is the editor of the EDG journal, the director of programs facilitates the sites and programs at our midyear and annual conferences, and the director of communications keeps the division membership informed by keeping our web site up to date. If you would like to know the details of the division, run for secretary/treasurer. For a rewarding experience, consider hosting a midyear meeting. No matter how you volunteer, you get to know more members of the division.

Being chair has been a rewarding experience. My job was made easy because of all the support I received from the directors and a special thanks to Aaron Clark who took over for me when I wasn't able to perform my responsibilities and to Norma Veurink and Kathy Holliday-Darr for answering all my questions.

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Message from the Editor: *EDGJ* Statistics

Robert A. Chin
East Carolina University

Google Analytics statistics on the online *EDGJ* website collected between September 27, 2010 and May 26, 2011 indicated that:

- The *Journal* site received 9,032 visits by 7,582 unique visitors
- Visitors generated 31,942 page views
- New visits accounted for 83.81% of the visits
- *Journal* visitors came from different 130 countries/territories
- Visitors from the United States accounted for about 40% (N=3,591) of the visits

So what is Google Analytics, or GA? GA is a service offered by Google that compiles visit and visitor statistics about a website. The purpose of compiling these statistics is to identify improvement opportunities and to improve Internet marketing.

On September 28, 2010, an *EDGJ* GA account was created and began collecting data. In addition to the aforementioned statistics, 64.39% of the visits through May 26, 2011 originated from five countries, as an example—see Table 1. In addition to the number of visits originating from these five countries, the number of pages viewed per visit, the average time on the site in minutes and seconds, and the proportion of new visits from these countries were among the statistics provided by GA.

Table 1

Top Five Countries/Territories from which *EDGJ* Visits Originated

	Visits	Pages/Visit	Avg. Time on Site	% New Visits
United States	3,591	6.01	3:18	78.06%
India	1,034	1.60	1:18	95.74%
United Kingdom	533	1.57	0:48	79.17%
Canada	373	2.03	1:17	93.03%
Philippines	285	1.52	1:13	93.68%

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ISSN: 1949-9167

Of potential interest to visitors of journal sites and to the authors of the feature articles are statistics on the most frequently visited feature articles. While there are additional statistics, the most frequently visited *EDGJ* feature articles, according to Pageview, between September 27, 2010 and May 26, 2011 appear in Table 2. Pageview refers to every instance of a visit, Unique Pageview refers to the number of sessions a particular page is viewed one or more times, and Avg. Time on Page refers to the average amount of time in minutes and seconds visitors spend on a given page.

Table 2

Top Five Feature Articles Visited

	Page-views	Unique Page-views	Avg. Time on Page
Developing 3-D Spatial Visualization Skills by Sheryl A. Sorby	748	564	3:07
Drafting the Basics by Carol M. Lamb and David G. Kurtanich	602	397	1:41
Spatial Visualization Measurement: A Modification of the Purdue Spatial Visualization Test - Visualization of Rotations by Theodore J. Branoff	524	391	2:29
Cam Design Projects in an Advanced CAD Course for Mechanical Engineers by H. K. Ault	337	243	1:48
Application of 3D CAD for Basic Geometric Elements in Descriptive Geometry by Daniel M. Chen	334	262	3:11

GA also offers a Weighted Sort feature which tempers the statistics collected and offers additional options for assessing site traffic. This feature weighs the results by associated columns.

For additional information on GA, go to http://www.google.com/analytics/. Hopefully the statistics provided by GA can assist the Division fine tune the *Journal* to meet its present users' needs and to begin meeting the needs other users. Periodic updates will be provided in this column. If anybody is interested in exploring GA's potential for improving the *Journal* site, feel free to let us know. The *Journal* is also in need of volunteers to scan past issues of the *Journal* for posting.

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The 2011-2012 Mid-Year Conference

Engineering Design Graphics Division's 66th Midyear Conference (2011-2012) takes place January 22-24, 2012 in Galveston, TX. Add this to your Outlook calendar.

Accommodations: Moody Gardens Resort and Convention Center—see www.moodygardenshotel.com. The guest room rate is the prevailing state rate, which is currently $ 88 per night—single and $ 109 per night—double.

The site chair is Ron Pare, the program chair is Judy Birchman, and Ron Barr and Tom Krueger are handling registration and exhibits.

Visit the following sites for the call and updates:

- http://edgd.asee.org/
- http://www.edgj.org/index.php/EDGJ/index

Also, if you are not an EDG listserv member, contact Eric Wiebe at: eric_wiebe@ncsu.ecu and he will get you subscribed. The call and updates will also be transmitted by means of the listserv.

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Election Results

According to the Division by-laws (see http://edgd.asee.org/aboutus/edgdbylaws.htm), the chair of the Elections Committee shall transmit the results of the election to the Chair of the Division. The Chair shall inform each candidate (including those not elected) of the results of the election for his office and shall transmit the names of the newly-elected officers to the Editor of the Journal for publication in the Spring issue of the Journal. The chair of the Elections Committee shall report the results of the election to the Division at the annual business meeting. The results for the most recent election are as follows:

For Vice-Chair: Nancy E. Study

Nancy E. Study is an Associate Professor in the Department of Engineering and Technology at Virginia State University where she teaches courses in engineering graphics, facility planning, and cost estimating. She has been active in the Engineering Design Graphics Division of ASEE since 1999, has presented a number of papers at the midyear meetings and annual conferences, and has served as Associate Editor of the Engineering Design Graphics Journal since 2006. As a co-author, Nancy is a previous winner of the EDG Journal Editor's award.

Nancy has a B.S. from Missouri State University and M.S. and Ph.D. from Purdue University. Her research interests are in visualization, haptics, and the integration of educational technology in STEM education. Her most recent work has focused on improving visualization abilities of minority engineering and technology students. She is also a member of Phi Kappa Phi and Epsilon Pi Tau honorary fraternities.

For Director of Communications: Nicholas Bertozzi

Nick is a Professor of Engineering at Daniel Webster College (DWC) and Dean of the School of Engineering and Computer Science (SECS). His major interest over the past fourteen years has been the concurrent engineering design process, an interest that was fanned into flame by attending an NSF faculty development workshop in 1996 led by Ron Barr and Davor Juricic. As a result of this workshop, in 1998 a three-semester engineering design sequence was introduced in DWC's two-year engineering program. The evolution of this program is described in the article, 'Implementation of a Three-Semester Concurrent Engineering Design Sequence for Lower-Division Engineering Students', and was published in the Winter 2007 American Society for Engineering

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Education (ASEE) Engineering Design Graphics Division (EDGD) Journal. The sequence was well received by the DWC engineering students and in 2005 the College introduced BS degrees in both aeronautical and mechanical engineering. The new BS programs both contain a five-semester design sequence. Engineering graphics and concurrent engineering are developed and exercised through-out the new curriculum. In 2006 DWC was accepted into the CDIO collaborative (www.cdio.org) and in July 2010 the aeronautical engineering program received ABET accreditation. A site visit for the mechanical engineering program is planned for fall 2010. Nick has a particular interest in helping engineering students develop good communications skills and has made this a SECS priority. Over the past six years he and other engineering and humanities faculty colleagues have mentored a number of undergraduate student teams who have co-authored and presented papers and posters at EDGD and other ASEE, CDIO, and American Institute of Aeronautics and Astronautics (AIAA) meetings as well. Recent DWC student team awards include the 2009 ASEE EDGD Chair's Award, first place in the team paper competition at the AIAA New England Region Student Conference, April 2010, second place in the student project poster competition at the ASEE Northeast Section Conference, May 2010, and tied for second place in the student project competition at the 2010 International CDIO Conference, Montreal, June 2010. He was delighted to serve as the EDGD program chair for the 2008 ASEE Summer Conference and is currently serving on the ASEE EDGD executive committee as the Director of Communications.

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The Editor's Award

The volume 74 *EDGJ* Editor's Award recipients are Holly K. Ault of Worcester Polytechnic Institute and Samuel John of Polytechnic of Namibia for their article Assessing and Enhancing Visualization Skills of Engineering Students in Africa: A Comparative Study. Their article was published in the Spring issue (number 2)—see http://www.edgj.org/index.php/EDGJ/issue/view/33

The Editor's Award recognizes the outstanding paper published in the previous volume of the *Engineering Design Graphics Journal* and includes a framed citation and a cash award, which are presented at the ASEE Annual Conference.

The award description can be found at http://edgd.asee.org/awards/editors/index.htm

A complete list of awardees list can be found at http://edgd.asee.org/awards/editors/awardees.htm

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The Media Showcase Award

The 2010-2011 Media Showcase Award awardees are A. Varricchio, M. Kelly, J. Donovan, J. O'Donnell, R. Kettner-Polley, J. Smith, and N. Bertozzi of Daniel Webster College; Ted Branoff of North Carolina State University; and Marie Planchard of Dassault Systemes SolidWorks, Corp. for their presentation entitled Development of EDGD Website Automated Learning and Assessment Resources. Their presentation can be found at http://edgd.asee.org/conferences/proceedings/65th%20Midyear/Bertozzi_Automated_Learning_Assessment_Resources_posters.pdf

The Media Showcase Award was established to encourage the highest level of professionalism in media presentations at the Engineering Design Graphics Division Midyear Conference and includes a framed citation and cash award. The Division's Chair announces the award recipient at the conclusion of the Division's Midyear Conference during the Awards Banquet.

The award description can be found at http://edgd.asee.org/awards/media/index.html

A complete list of awardees list can be found at http://edgd.asee.org/awards/media/awardees.html

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The Oppenheimer Award

The 2010-2011 Oppenheimer Award recipient is Nancy E. Study of Virginia State University for her paper *Long-term Impact of Improving Visualization Abilities of Minority Engineering and Technology Students: Preliminary Results*. Dr. Study's paper appears on the following pages.

The Oppenheimer Award was established by Frank Oppenheimer to encourage the highest level of professionalism in oral presentations at the Engineering Design Graphics Division Midyear Meeting. The award includes a framed citation and cash award. At the conclusion of the Midyear Conference, the Chair announces the recipient during the Awards Banquet. The Oppenheimer Award is funded by a yearly cash award by the Oppenheimer Endowment Fund.

The award description can be found at http://edgd.asee.org/awards/oppenheimer/index.htm

A complete list of awardees list can be found at
http://edgd.asee.org/awards/oppenheimer/awardees.htm

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ISSN: 1949-9167

Long-term Impact of Improving Visualization Abilities of Minority Engineering and Technology Students: Preliminary Results

Nancy E. Study
Virginia State University

Abstract

Previous studies found that students enrolled in introductory engineering graphics courses at a historically black university (HBCU) had significantly lower than average test scores on the Purdue Spatial Visualization Test: Visualization of Rotations (PSVT) when it was administered during the first week of class. Since the ability to visualize is linked with success in engineering and technology studies, changes to the courses were made that resulted in improvement of these students' visualization abilities. Activities included the use of sketching, blocks and multimedia. It was hypothesized that improving the students' visualization abilities would also improve their overall academic success. Retention in the major and graduation rates of minorities in STEM related fields tend to be lower than their non-minority peers, especially so at HBCUs. To assess the long-term impact of visualization remediation on student success in engineering and technology majors, data was collected on students in a test group and also those in a control group who enrolled in other sections of the engineering graphics courses. Statistics were compared for overall GPA and grades in math and physics courses. Other data gathered included whether the students were retained in the major and at the university. Significant differences were found in the students' GPAs with higher averages earned by those students in the test group. Also a higher percentage of students in the test group were retained both in an engineering or technology major and at the university even if they did change their major.

Introduction

Beginning in 2003, data was gathered on the visualization abilities of students enrolled in introductory engineering graphics courses at Virginia State University (VSU), an HBCU. These subjects had significantly lower than average scores on the Purdue Spatial Visualization Test (PSVT) (Guay, 1976) when it was administered during the first week of the semester. The visualization abilities of these subjects were improved through a variety of methods including sketching, haptic activities and multimedia exercises. The content of the courses varied slightly throughout the years referenced in this study but consistently covered the topics of orthographic projection, section views, auxiliary views, basic dimensioning and creation of technical drawings in both 2D and 3D CAD (Study, 2006, and Veurink, et al., 2009).

The overall national average college graduation rate for black students has improved over the last several years but at 43 percent it is still quite low when compared to 63 percent for white students. At HBCUs however, the graduation rate is even lower with an average of less than a third of all students who enrolled in an HBCU completing bachelor's degrees. Curricula oriented toward the sciences also tended to have lower graduation rates for blacks than those in the liberal arts. The high attrition rates are often attributed to inadequate K-12 preparation (Black student college, 2007). At VSU,

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the mean freshmen cohort graduation rates have increased over time. The earliest data available was from 1992 when the cohort had a four year graduation rate of 5%, a five year rate of 21.7% and a six year rate of 25.6%. The most recent data available is for the cohort that entered in 2003, and the average graduation rates over time for students at VSU are 18.8% in four years, 33.4% in five years, and 38.5% in six years (State council, 2010).

Since improving visualization abilities has been linked to better grades and retention, (Sorby, 2009) in other studies, longitudinal data is in the process of being collected on the students who enrolled in sections of engineering graphics courses that had specific instruction focusing on visualization. This data is being compared to that of students who were enrolled in other sections of the courses taught by different instructors where no additional visualization activities were included in the instruction.

Visualization Instruction

From Spring 2004 through Spring of 2007, students enrolled in the test sections of the engineering graphics courses were given assignments that focused on sketching and visualization both in class and for homework. Students also were required to turn in sketches of solutions before beginning work on CAD drawings. The sketching exercises included missing view and missing line problems, multiview sketches from isometric drawings, and section and auxiliary view exercises. The assignments ranged from 6 to 20 sketches. Written tests and quizzes throughout the semester also contained sketching components as well as the final comprehensive exam. Sketching activities comprised approximately 40% of the overall grade in the courses (Study, 2006).

Beginning in Fall 2007, as part of the EnViSIONS project (Veurink, et al, 2009), students enrolled in test sections of the engineering graphics courses completed modules of the textbook Introduction to 3D Spatial Visualization: An Active Approach workbook and software by Sorby and Wysocki (2003). Topics covered in the workbook included: isometric sketching, orthographic projection, flat patterns, rotation of objects, object reflections and symmetry, cutting planes and cross sections, surfaces and solids of revolution, and combining solids. The workbook modules were primarily assigned as in class work. Other class work consisted of instruction in CAD, dimensioning, drawing standards, and file management.

The effect of the visualization instruction, regardless of the method, showed improvement in the subjects' visualization abilities as measured by the PSVT. The grand mean pretest score for 156 subjects across multiple studies was 15.4 out of a possible 30 points which was significantly below the expected score for freshman engineering and technology students. The grand mean posttest score across the multiple studies was 19.88 which approached the expected mean and the improvement was statistically significant. In order to assess whether the instruction and subsequent improvement of visualization abilities had any long term effects, longitudinal data including grade point average and retention was collected.

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Subjects' Longitudinal Data

Of the students who received instruction specifically intended to improve their visualization abilities, complete follow up data is currently available on 21 male and 9 female subjects in the test group. Data was also gathered on a control group of 30 male and 3 female subjects who enrolled in sections of the engineering graphics courses that did not receive the visualization specific instruction. Of the 63 total subjects, 98% self identified as black.

Grade Point Average

The mean overall GPA of the students in the test group was 2.69 compared to the control group mean of 1.91. It is recommended, but not required for all majors, that students maintain a 2.0 GPA in their major courses regardless of overall GPA. VSU's undergraduate catalog requires that

> A new student (freshmen or transfer student without an Associate Degree) must earn a minimum grade point average of 1.5 each semester during the first two regular semesters in residence. Thereafter, the student must earn at least 2.0 semester average each regular semester (to avoid Academic Warning) or have a cumulative average of 2.0 (to avoid Probation or Suspension).
>
> Transfer students with the Associate Degree must maintain a 2.0 semester average each regular semester (to avoid Academic Warning) or have a cumulative average of 2.0 (to avoid Probation or Suspension) to remain in good academic standing (Virginia State University, 2010).

The calculation of overall GPAs included the final GPA of graduating seniors, the final GPA of students who left the University, and the GPA of currently enrolled students ending the Spring semester of 2010. These GPAs were from two to five semesters after the subjects were enrolled in either a test or control section of the engineering graphics course.

The GPA in the subjects' math and physics courses was also collected. Math courses used to calculate the average ranged from introductory college algebra to calculus. At VSU, students receive separate grades for physics lectures and labs and both lecture and lab grades were used in the calculations in this study. Students in the test group had an overall math GPA of 2.49 and a physics GPA of 1.97. Control group subjects had a math GPA of 1.13 and a physics GPA of 0.80.

Retention Rates

Of the 30 students in the test group, 12 graduated, 16 are still retained in their major, 1 changed major, and 1 withdrew from the university. Of the 33 students in the control group, 2 graduated, 20 remain enrolled in their major, 1 changed major, and 10

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withdrew from the university. Not all those students who left the university were suspended because of a low GPA.

Analysis

Grade Point Averages

Using a t-test to compare the overall grade point averages of the test versus control group (Table 1) found the test group had a significantly higher GPA.

Table 1. Overall GPA

	Mean	SD	p
Test Group	2.69	0.594	0.00
Control Group	1.91	0.621	

The t-tests that compared the math and physics grade point averages were also significant as shown in Tables 2 and 3 with subjects in the test group having significantly higher GPAs.

Table 2. Math GPA

	Mean	SD	p
Test Group	2.49	0.961	0.00
Control Group	1.13	0.743	

Table 3. Physics GPA

	Mean	SD	p
Test Group	1.97	0.841	0.00
Control Group	0.80	0.922	

Retention and Graduation Rates

The students in the test group had a higher graduation rate when compared to those in the control group, 40 percent versus 6 percent. Students in the control group had a

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higher rate of withdrawal from the university although 61 percent were still retained in their major (Table 4).

Table 4. Retention and Graduation Rates

	Graduated		Retained in Major		Changed Major		Withdrew	
	N	%	N	%	N	%	N	%
Test Group	12	0.40	16	0.53	1	0.03	1	0.03
Control Group	2	0.06	20	0.61	1	0.03	10	0.30

Discussion

In 2006, blacks earned 8.7% of all science and engineering degrees while they represented 12% of the US population. Of the total students enrolled at HBCUs, 17% were studying science and engineering fields (National Science Foundation, 2009). However, the graduation rates at HBCUs were typically even lower than non-minority serving institutions (Black student college, 2007). Reasons for the lack of success in STEM fields vary but are often attributed to lack of pre-college preparation. Since academic success in STEM fields is associated with abilities in spatial visualization, the low pretest PSVT scores of the subjects in this study were of concern.

After implementing visualization specific instruction in introductory engineering graphics courses, students who were below average in their visualization abilities had posttest PSVT scores that were approximately equal to the expected mean. When this test group was compared to students who did not receive the visualization instruction, the control group, the test group's subjects had significantly higher overall grade point averages and significantly higher GPAs in their math and physics courses. A direct comparison of graduation rates is not appropriate because the students in the control group are primarily sophomores and juniors. However, the control group did have a larger rate of withdrawal from the university, 30% compared to 3% of the test group.

Whether the visualization instruction used a workbook, blocks, and multimedia instruction (Veurink, et al, 2009) or sketching exercises such as missing view and missing line problems, multiview sketches from isometric drawings, and section and auxiliary view exercises (Study, 2006), and whether the CAD portion of the course focused more 2D or 3D, all instruction involved orthographic projection and some form of sketching and haptic interaction with physical objects. The skills learned from these activities help students create mental models that can aid in interaction with abstract concepts across the curricula, especially in their math and science studies. This may be indicated by the higher GPAs and graduation rates of the subjects in the test group.

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Longitudinal data is still being collected on subjects who have received visualization instruction and it will be compared to students in the control group. Additional analyses will be conducted comparing the long-term success of the students in the two groups including retention based on how long after completing either a test or control section of the engineering graphics course the students remain enrolled and/or graduate.

Due to the small sample size and not controlling for a variety of external factors including inconsistencies in academic advisement, financial aid status, whether or not the student was working and if so, how many hours a week, firm conclusions cannot be drawn from the results. However, the initial data does suggest that the visualization instruction be continued because of the potential positive long-term effects.

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About the Author

Nancy E. Study is an associate professor in the Department of Engineering and Technology at Virginia State University, where she has taught since 2002. She is an active member of the Engineering Design Graphics Division of ASEE and has served as the Associate Editor of the Engineering Design Graphics Journal since 2006. Study has served as a reviewer of conference abstracts and papers for the Engineering Design Graphics Division's Annual and Mid-Year conferences, along with serving on multiple NSF review panels. Her research interests include haptics and visualization.
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Engineering Design Graphics Journal (EDGJ)
Spring 2011, Vol. 75, No. 2
http://www.edgj.org

ISSN: 1949-9167

A Qualitative Study Examining the Spatial Ability Phenomenon from the Chinese Student Perspective

Helen W. Kang, James, L. Mohler, and Soyoung, Choi
Purdue University, West Lafayette, Indiana

Yuehua Chen and Chunhui Zheng
Harbin Institute of Technology, Harbin, China

Abstract

The authors used holistic and structured interviews to examine Chinese student perspectives on their own spatial ability. The results of this study were compared and contrast with a previous study that was conducted by Mohler (2008) of Caucasian student perspectives in United States. Findings of the current study agree with other literature that Chinese student spatial ability may be culturally formed. Their background, experiences, and upbringing may contribute to Chinese student development of spatial ability and appear to differ significantly from students in United States. Recommendations and educational implications are discussed in the following contribution.

As an educator in the field of graphics and engineering, Mohler (2008) questioned whether suitable intervention techniques would improve student spatial ability. There is a general agreement that spatial ability involves one's mental operation. Lohman defined spatial ability as being related to one's ability to mentally "generate, manipulate, and retain abstract information and/or images" (1979, p. 188). Spatial ability has been acknowledged to be integral for success not only in engineering graphics but also in architecture, art, design, and the medical field. Thus, early intervention to improve spatial ability for individuals is critical.

There are different opinions regarding whether spatial ability is innate or acquired through experience (El Koussy, 1935). Thurstone (1938) and Piaget and Inhelder (1971) strongly agreed that spatial ability is an innate ability. Nevertheless, numerous studies have argued that spatial ability can be obtained and improved through appropriate motivation, training, and activities (Kang & Mohler, 2010; Lohman, 1993; Sorby, 1999). There are many inconsistencies regarding the effects of practice and training on spatial ability (Kyllonen, Lohman, & Snow, 1984; Salthouse, Babcock, Mitchell, Palmon, & Skovronek, 1990), that is, some individuals still struggle with spatially related tasks even with specifically designed intervention. Also, variances in spatial performance among age, gender, and different ethnicities have emerged throughout these studies (Demetrious, Kui, Spanoudis, Christou, Kyriakides, & Platsidou, 2005; Peters, Lehmann, Takahira, Takeuchi, & Jordan, 2006; Silverman, Choi, & Peters, 2007).

Mohler (2008) noted that many studies focused only on developing specific training methods to enhance one's spatial ability even if one does not benefit from it. No one has considered the effect of an individual's perspective and experiences that may contribute to spatial ability using a qualitative method until recently (Mohler, 2008). The current study examined the perspective of Chinese students regarding their own spatial ability. Furthermore, a qualitative approach to the current study provided unique information regarding cultural experiences that may influence the Chinese student's spatial performance compared with students in the United States.

Relevant Literature

Individual differences in spatial ability have been studied by a number of researchers. Differences in age, gender, and strategies that are used to solve spatial problems have been more widely studied. There has been a recent interest in examining the spatial ability between different racial ethnicities (Demetrious, Kui, Spanoudis, Christou, Kyriakides, & Platsidou, 2005; Peters, Lehmann, Takahira, Takeuchi, & Jordan, 2006; Silverman, Choi, & Peters, 2007). For instance, Silverman, Choi, and Peters (2007) compared the difference in spatial ability performance over 40 countries and Demetrious and others (2005) compared the performance of over 3,000 participants with various ethnicities. These studies have attempted to unlock the secret of why one race was able to outperform others in spatial tasks.

One of the reasons behind the latest interests could be due to the variances of academic success that have been displayed among racial ethnicities in the learning environment. General academic success is assumed to be closely correlated with spatial ability. Over the years many studies acknowledged that student mathematics achievement is highly correlated with spatial ability (Kang & Mohler, 2010). Specifically, student scores on the visualization factor of spatial ability appear to be associated with their ability to learn geometry (Kang & Mohler, 2010). Therefore, studies have examined the spatial ability phenomenon among ethnic races in an effort to identify the reasons behind the academic success in mathematics.

It has been acknowledged that many East Asians (Japanese, Chinese, Korean, and Thai for example) tend to outperform Caucasians in mathematics. Some researchers claimed that the Asians' performance and achievement in mathematics could be attributed to the method of mathematics teaching and curricula that are outlined within their country's educational policies (Geary, Salthouse, Chen, & Fan, 1996; Wang & Lin, 2005). This is reasonably credible because studies have acknowledged the vigorous nature of content coverage, instructional requirements, and structures that were demonstrated in East Asian countries. However, educators have criticized this aspect of teaching by indicating that these students may be able to perform the arithmetic (which includes skills in addition, subtraction, multiplication, and division) but they lack reasoning capabilities (Wang & Lin, 2005).

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Other studies have speculated that Chinese student success in mathematics appears to begin even before they enter kindergarten and, consequently, performance differences between Chinese and Caucasians escalate as both groups move through their formal schooling (Huntsinger, Jose, Larson, Krieg, & Shaligram, 2000; Wang & Lin, 2005). East Asian teaching techniques, student self-expectation, and family involvement in their children's education have been acknowledged as factors contributing to these differences.

However, one of the more interesting factors that studies have depicted was that Chinese student mathematic ability is greatly influenced by the Chinese language itself (Li, Nuttall, & Zhao, 1999; Stevenson & Stigler, 1992). As indicated earlier, spatial ability plays a crucial role in student understanding of mathematics. Spatial ability also appears to be highly correlated with their performance in geometry. Respectively, Chinese students outperform Caucasians by at least 15 points in spatially related tasks (Jensen, 1998), a trend that has been exhibited in numerous other studies as well (Demetrious, Kui, Spanoudis, Christou, Kyriakides, & Platsidou, 2005; Peters, Lehmann, Takahira, Takeuchi, & Jordan, 2006; Silverman, Choi, & Peters, 2007). Studies assert that not only does Chinese language appear to convey mathematical concepts better than English, the ability to read and write Chinese characters also may play a fundamental role in the development of spatial ability (Demetrious, Kui, Spanoudis, Christou, Kyriakides, & Platsidou, 2005). Hence, persons who can read and write Chinese could have a higher spatial ability, which can lead to a better success rate in mathematics.

Researchers claimed that Chinese speakers use the visuo-premotor part of the brain to process mathematical information. Thus, when a Chinese speaker is given a mathematical problem, the information that is written in Chinese characters is decoded and processed as a shape and converted as non-language contents (Tang, et al., 2006). When Chinese linguistics was further investigated, the Chinese characters appear to be constructed based on meaning rather than phonology (Ho & Bryant, 1999). Also, Chinese usually is written without spaces; most words are formed by two or more characters (Bai, Yan, Zang, Liversedge, & Rayner, 2008). Therefore, significant spatial and visual-orthographic awareness is needed by the reader as Chinese does not have spaces and contains "high visual complexity" (Tang, et al., 2006, p. 8781). Furthermore, the Chinese numeral is constructed based on the ten numbering system, which may assist learners with counting and arithmetic skills (Wang & Lin, 2005). These reports were also supported when native Chinese students and Chinese-American students performed mental rotation tasks (Li, Nuttall, & Zhao, 1999). This particular study concluded that those students who were able to read and write Chinese scored significantly higher in the mathematics portion of the SAT and mental rotation tasks than those students who could not read or write the language.

The literature has indicated various factors that may be attributed to Chinese student spatial ability. The current study conducted interviews as a primary method to determine whether Chinese student perspectives on spatial ability are culturally formed. The

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particular areas of Chinese student experiences and background were observed. Moreover, the previous study conducted by Mohler (2008), which examined the perspective of high and low spatial performers in the United States, was compared with Chinese participants of the current study.

Significance

As stated by Mohler (2008), quantitative research has been widely used to measure the unique nature of spatial ability among individuals. However, there has been little research conducted in order to understand why some participants succeed or fail in performing spatially related tasks. The performance differences that were demonstrated among different racial ethnicities are even more difficult to answer. Literature indicates that this difference in spatial ability may be cultural in nature and questioned whether spatial ability is culturally formed (Silverman, Choi, & Peters, 2007; Tang, et al., 2006; Wang & Lin, 2005). Studies suggested that qualitative research may be the key to discovering how spatial ability is culturally formed. Examining participant background, experiences, and environmental factors may explain this particular phenomenon (Demetrious, Kui, Spanoudis, Christou, Kyriakides, & Platsidou, 2005; Silverman, Choi, & Peters, 2007; Wang & Lin, 2005).

Purpose

Mohler (2008) conducted a research study in efforts to answer the question: "What was it like for a student to experience the spatial ability phenomenon?" He analyzed the background, life experiences, and perspectives of typical engineering students in the United States who performed at varying levels in spatial tasks. The purpose this present study was to compare and contrast Mohler's (2008) study and pose the same research question relative to Chinese students. The study examined whether there are differences in Chinese student perspectives toward the spatial ability phenomenon due to dissimilarity in culture, life experiences, and upbringing.

Methodology

The sample for this study was selected from students in Media Technology who were enrolled in *Spatial Ability – Research & Assessment,* a course held during the fall semester of 2009 at Harbin Institute of Technology in China. The participants were graduate students who were in their third and fourth semesters of their master's degree. The major concentration of this group of students varied from 3D modeling and animation to visual effects and multimedia.

As suggested by Mohler (2008) and Patton (2002), a qualitative study and design can be used to investigate the spatial ability phenomenon of individuals in extreme and unusual cases. For this reason and also to replicate Mohler's study, Chinese participants (n = 35) were given the Vandenberg Mental Rotation Test (1971) as an in-class activity. The Vandenberg Mental Rotation Test has been acknowledged as a

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reliable instrument to measure spatial ability due to its validity and convenience. Specifically, when the test and retest of the Vandenberg Mental Rotation Test was performed, Vandenberg and Kuse (1978) reported the reliability value of .83. Once the tests were scored (M = 12.31, SD =5.41), those students who scored high (3.5 standard deviation units above the mean) and low (3.5 standard deviation units below the mean) on this test were selected as extremes among individuals.

There have been varying opinions concerning the number of participants that are required for single case qualitative studies. Mohler (2008) interviewed 12 students, but the numbers of participants can range from three to 10 participants when one is trying to understand subject experiences and background (Creswell, 1998). In an effort to meet the high end of participant numbers suggested by various studies, eight subjects participated in the study for in-depth interviews.

Data Collection

Scores for the Vandenberg Mental Rotation Test were rated to depict students with the high and low spatial ability. Four students who scored high and four students who scored low in MRT were selected and they participated in approximately 90-minute interviews in English. Due to the language barrier among participants, some of the interviews lasted under 90 minutes. As suggested by Mohler, interviews were divided into two subsections. The first part of the interview was designed to understand background and experiences that might have affected participant perspectives on spatial ability. The second part of the interview consisted of a summative activity in which participants reflected on their development of spatial ability through their daily activities. The interviews were administered with pre-determined questions for consistency. Interview questions were developed based on the findings of Mohler (2008) to facilitate a comparative analysis between Mohler (2008) and this current study. All interviews were audio-recorded.

Data Analysis

The researchers followed the coding procedures of Mohler (2008). In Mohler's (2008) study, he used three procedural steps of bracketing, intuiting, and describing as a method of analysis. This particular method of analysis procedure was also suggested by Giorgi (1985 & 1997). A similar approach was used in the present study. Bracketing sets aside presupposition and examines overall textual descriptions within the data. Intuiting requires the development of meaning units that are used to summarize sections of the textual description. Describing is the process of creating a structural description of the meaning units (Giorgi, 1985).

Interviews were transcribed without pre-determined coding scheme to identify participants' background and experiences that might have affected perspectives on spatial ability. Any identified codes were used as an evolving lens to reread the data and the patterns emerging across students were explored. Based on this preliminary

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ISSN: 1949-9167

analysis, coding scheme of students' background and experiences was developed, tested and revised by several rounds of analysis. A comparative analysis was conducted to find similarity and differences in background and experiences between low and high Chinese participants and also with participants studied by Mohler (2008). To triangulate data analysis and ensure consistency in coding, the researchers participated in coding a subset of data.

Invariant Themes

Based on the interviews with Chinese participants, researchers were able draw out five specific themes related to the participant perspectives on spatial ability development. Comparable themes also appeared in Mohler's (2008) study which included childhood toys, musical experiences, favorite school subjects, parental involvement, and feelings. The following section is divided into these themes to discuss the findings in further detail.

Childhood Toys

Some effective spatial ability interventions include using animated visuals and/or providing physical hands-on activities such as Lincoln Logs, Tinker Toys, and Legos (Anglin, Towers, & Moore, 1997; Pak, 2001). These tools have emerged because many studies claimed that spatial ability is not an innate ability but one that can be nurtured by the right tools and experiences. Specifically, Thurstone (1938) and Piaget and Inhelder (1971) strongly agreed that spatial ability is an intelligence that is presented at birth. Nevertheless, numerous studies have argued that spatial ability can be developed and improved through appropriate motivation, training, and activities (Alderton, 1989; Lohman, 1993).

Mohler (2008) reported in his study that both high and low spatial performers acknowledged playing or having access to Legos. Both high and low spatial Chinese participants of the current study indicated that they also had access to Legos (they referred to Lego as *Jimoo* in Chinese) or different types of building blocks. Interestingly, low spatial participants indicated that they rarely played with these particular toys. See Table 1 for more details regarding the differences between high and low spatial Chinese participants of the current study and Mohler (2008).

Musical Experience

Over the last 30 years, psychological music researchers have reported that individuals with musical experiences performed significantly higher in spatial cognition tasks (Mohler, 2008; Tai, 2010). Studies also indicated that musical involvement had a positive association with other cognitive abilities, such as in mathematical and verbal tasks. Also, formal exposure to music during childhood has a small but positive impact on student IQ and academic performance (Schellenberg, 2006). Consequently, the

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current study interviewed Chinese students to see whether participant musical experiences had influenced their perspectives on spatial ability.

Table 1.
Comparison between Mohler (2008) and the Current Study

Themes	Current Study (2010)	Mohler (2008)
Childhood Toys	Low participants rarely played with Legos & Building Blocks.	Both High and Low Participants played and had access to Legos.
Musical Experience	Did not indicate any association between musical experiences and spatial ability.	Indicated visualizing music by hearing musical notes in mind and play by the ears.
Favorite School Subjects	High participants: Mathematics Low participants: Reading and Writing	High participants: Mathematics Low participants: Reading and Writing
Feelings	All participants showed frustration, confusion and intimation	
Parents Involvement (New Emerged Theme in the Current Study)	Great parental involvement for high participants in academic achievement. (Possibly due to parents' educational background and occupations.)	

*Highlighted: themes that indicated possible association with spatial ability

Almost all of the Chinese participants had some type of musical experiences. Both high and low spatial performers had various musical lessons (e.g., violin, harp, piano, guitar, and Chinese flute), and indicated that these lessons started at a very young age (two to four years of age). Only one of the high spatial participants was still playing an instrument and was a member of band. Other remaining low and high spatial performers reported that they quit playing instruments after several years of lessons. Also, these participants did not report any association between musical experiences and spatial ability, what Mohler described as "visualize music by hearing the musical note in mind and play by the ear" (p.6, 2008), in their short musical experiences.

Favorite School Subjects

Numerous studies stated that students with higher spatial ability also perform significantly better in mathematics than students with low spatial ability. Studies also indicated that person who can read and write Chinese have demonstrated greater performance in spatial tasks (Demetrious, Kui, Spanoudis, Christou, Kyriakides, & Platsidou, 2005; Li, Nuttall, & Zhao, 1999; Stevenson & Stigler, 1992). Therefore, researchers presumed that Chinese students with high spatial ability might indicate their favorite school subject as reading or writing Chinese. Surprisingly, high spatial ability participants reported that their favorite subject was mathematics and believed themselves to be strong in the subject. The low spatial ability participants indicated their

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preference toward reading and writing as their favorite subjects. The participants stated that they found mathematics rather difficult and uninteresting. This result was also shown in Mohler's high and low spatial participants.

Parental Involvement

One of the factors that might be attributed to Chinese students' success in mathematics and spatial ability could be parental involvement in their children's education (Wang & Lin, 2005). Many studies concluded that parental support for Chinese students is stronger than parental support for students in the United States. Chinese parents usually set up more structured time frames to assist their children's instruction after formal schooling. Furthermore, Chinese parents set higher goals for their children to succeed in mathematics. These efforts appear to play a leading role in Chinese students' higher achievement in mathematics (Wang & Lin, 2005).

Therefore, it was not unexpected to discover much more of parental involvement for Chinese participants with higher spatial ability. When high spatial participant backgrounds were further analyzed, the current study revealed that parental occupations were things such as engineer, professor, accountant, and teacher (i.e., white collar workers). The parents of low spatial performers were farmers, policemen, and workers at the local factory (i.e., blue collar workers). This is a new theme that emerged from the current study of Chinese students and their perspectives of spatial ability compared to Mohler's previous (2008) study.

Feelings

Mohler (2008) stated that almost all of his participants showed some level of frustration, confusion, and intimidation when they were given spatial tasks. He also concluded that the level of these feelings might obstruct participant ability to solve problems. A majority of Chinese participants stated that they also felt less confident about their spatial ability. Only two of the high spatial participants indicated that they were strong spatial performers. Most participants felt frustrated and intimidated while taking the Vandenberg Mental Rotation Test.

Studies have specified that even though Chinese students felt less confident about their ability and skills, they do substantially better in mathematics and spatially related tasks than students in the United States. Perhaps one of the reasons behind their increased performance in mathematics or in other cognitive tasks could be because Chinese students devote more time and effort to their learning. A significant number of East Asian students view their academic success and failure on their own and they take personal responsibility for success or failure. When Chinese students feel less sure of their skills, they drive themselves to achieve better scores by devoting more time and effort to the subject matters. Therefore, this perspective could motivate Chinese students to attain higher achievement rather than hinder their performance in the area in which they lack confidence. Even though Chinese participants felt intimidated and

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frustrated with the spatial problems, the feeling may motivate them to do better on the task (Wang & Lin, 2005).

Conclusions

There have been countless efforts to enhance student spatial ability. Many interventions have been developed and tested to measure their effectivness. However, these interventions have not worked wholly with all groups and people. Spatial ability is necessary to perform any job at an adequate level. Approximately half the adult population has difficulty with spatial ability, and researchers have found that a lack of spatial skill has hindered adult career progression (Maccoby & Jacklin, 1974; McGee, 1979). The purpose of current study was to investigate Chinese student background and experiences and how these factors might contribute to student spatial ability. Studies revealed that Chinese students usually outperform students in the United States in mathematics. Also, spatial performance of Chinese students, which is associated with success in mathematics, is higher than spatial performance of Caucian students in the United States. Thus, the findings of the study may allow educators to examine and develop appropriate methods to nurture student spatial abilty. Furthermore, researchers may be able to apply these methods to students in United States and perhaps influence their choice of future careers.

The current study revealed that both high and low spatial performers had access to Legos and building blocks that provided physical hands-on activities. However, low spatial participants spent more time playing with friends than participating in hands-on activities. The researchers also found it interesting that even though the majority of participants were females, they were provided Legos and buildings blocks as childhood toys. Specifically, one of the participants in high spatial group said:

> "Yes, I played with Jimmo (indicating Legos in Chinese). I think everyone had one when they were little to aum… building. Build tall building and then aum… break."

It was suggested that there are differences in spatial ability between genders because males were nurtured with these types of toys when they were young and females were not. Legos and building blocks have been recognized as toys that facilitate spatial ability, but females are usually given dolls and stuffed animals. Researchers speculated that because of the Chinese one-child policy, the parents may have wanted to provide their child with a variety of toys regardless of their child's gender.

Consistent with the literature, musical experiences during childhood also assist in developing spatial ability. Even though most participants had musical experiences that ranged from playing instruments to formal training in voice, they did not associate musical experiences as a factor that may have attributed to their spatial ability. This claim may be due to the fact that the majority of students had a very short musical experience. Studies claimed that Chinese students spent more time studying to improve

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their performance in general academics. For example, students are encouraged to set a specific time frame after school to study mathematics rather than participate in extracurricular activities such as music (Wang & Lin, 2005).

Chinese parents usually join their child when they are studying after school in order to provide additional support. Parental involvement in Chinese student learning is much stronger than parental involvement in the United States. These additional efforts appear to play a leading role in higher achievement of Chinese students in school. High spatial Chinese participants' parents were more involved in their studies, perhaps, because the parents were white collar workers (e.g., teacher, professor, and engineer) who may themselves be highly educated or who understand the importance in obtaining formal education.

Because of the correlation between spatial ability and mathematics, it was not surprising to find that high Chinese spatial performers indicated mathematics as their favorite subject. Literature claims that students who can read and write Chinese may have a higher spatial ability because Chinese linguistics are formed with high visual complexity. However, none of the participants stated that Chinese reading and writing were their favorite subjects. Especially low spatial participants felt that mathematics were very difficult for them to comprehend. On contrary, when the same question was asked to high spatial participants, all participants indicated mathematics as their favorite subject. Especially, one of the participants said:

> "Mathematics have multiple parts, I really liked geometry, but not numbers…I liked theories, problems, lines and drawings in geometry."

A lack of confidence in the subject also emerged when the researchers asked the participants how they viewed their own spatial ability. Almost all participants voiced confusion, intimidation, and uncertainty. Studies indicated that these feelings may actually help the Chinese student performance. When the Chinese students recognize their weakness in an area, they are more likely to put extra time and effort to improve their skills. Therefore, it would be interesting to perform a longitudinal study to observe the Chinese student performance for a longer period of time with suitable support and guides from the educator to see if these feelings subside.

The background, experience, and upbringing of Chinese students are significantly different due to culture. The current study provides valuable information that educators and parents may use to develop and nurture spatial ability of students in the United States. It appears that the Chinese student perspective on spatial ability and their performance may indeed be culturally formed. With the use of qualitative research methods, this study found that early intervention is a key to success in spatial ability. First, it is important to understand the spatial phenomenon of an individual. Second, as educators or parents, it is necessary to provide a variety of toys to a child, encourage participation in musical experiences, and be involved in the child's learning process.

Lastly, the current study concludes that these steps may benefit every individual; it is not limited to whether the student is Chinese, Caucasian, or another ethnicity.

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Engineering Design Graphics Journal (EDGJ)
Spring 2011, Vol. 75, No. 2
http://www.edgj.org

ISSN: 1949-9167

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