AC 2011-2044: DESIGN AS A METHOD OF INSTRUCTION IN CHINA

Steve Macho, Buffalo State College

Steve Macho is currently an Assistant Professor of Technology Education for SUNY at Buffalo State College. He completed a BS at St Cloud State University, and M.A. & Ed.D. in Technology Education at West Virginia University. Steve is a Minnesota farm boy who has been involved in technology his entire life. He has worked at Los Alamos National Laboratory, New Mexico Highlands University, and on various grants funded by the US Department of Education, NASA, and Microsoft. He became a member of the Oxford Roundtable in 2008 and presented at the roundtable again in 2010. Dr Macho recently began to collaborate with the China National Institute for Educational Research on matters of technology, engineering and design education.

Su Wang, China National Institute for Educational Research

Design as a Method of Instruction in China

Abstract

The Chinese are contemplating alternate methods for teaching technological and engineering literacy in their public schools. The China National Institute for Educational Research sponsored a workshop titled "Design as a Teaching Method" at the Beijing National Science Technology Museum in October 2010. This workshop was delivered by faculty from Buffalo State College of the State University of New York (SUNY), who were partially supported by a gift from the SolidWorks Corporation.

Data were gathered on pre/post evaluation forms, which included questions with a five-point Likert scale and open ended questions (as anecdotal evidence). A comparison of responses across the pre/post instruments revealed changes in perception on the use of design as a method of instruction. While there was only one significant finding, there were interesting implications. Finally, recommendations for the use of design-as-a-method-of-instruction are presented.

Introduction

The Chinese *National Curriculum Standard for Technology Education for High School*, released in 2004 by the Ministry of Education, states the technology course should focus on the development of students' technology literacy. The technology course could be design-based and centered upon hands-on practice. Chinese students are expected to integrate ethical considerations in their problem-solving scenarios and factor in aspects of economics, law, psychology, environment protection, and aesthetic appreciation, as they are applicable to the development of possible solutions to given problem scenarios.

On October 21-23 the China National Institute for Educational Research (CNIER) sponsored faculty from Buffalo State College to conduct a workshop titled: "Design as a Teaching Method." The workshop was also supported by the SolidWorks Corporation. SolidWorks provided 20 laptops, an expert professional trainer, and support for translating materials to Chinese. The location of the workshop was the Beijing National Science Technology Museum. The museum is a truly world-class museum located near the Olympic Birds Nest in the heart of Beijing. Most of the sixty people who attended the workshop were teachers. In addition to their participation in learning about using design as a method of instruction, these teachers provided responses on surveys that recorded their reactions, perceived potential, and perceived barriers of the application of design as a method of instruction in their classrooms.

The three-day workshop was led by Dr. Steve Macho. Lectures on use of design as a method of instruction included: problem identification & definition, developing a design statement & design brief, research, creative problem solving, selection of a solution, building a prototype, testing & evaluating the proposed solution, and reiteration of the process as necessary. The participants experienced a combination of all these portions of the design process with an emphasis on the "creative act" and "hands-on" participatory learning leading to technological literacy.

Established in 1957, CNIER is a research arm of the Ministry of Education. It is the only national level comprehensive education research institute in China. As the think tank for education innovation and development in China it employs more than 200 full time researchers.

These researchers studies cover almost all the topics in education: namely education policy, education theory, basic education, higher education, vocational education, teacher education, curriculum and pedagogy, international comparative education, psychology and special education, and physical, health, and arts education. CNIER researchers are contributing to the education development in China by advising policy-making process, advancing theoretical innovation and guiding local practices.

CNIER also supports the Future Engineers program, a student science and engineering competition. The Future Engineers national network was used for recruitment of workshop participants. Notices (official documents) were sent from CNIER to the Beijing Center for Students Activity; independent facilities for after-school student experiences. This center is a science, technology, and arts focused group that organizes teacher training, professional development, student clubs, and student competitions. This center is affiliated with the Beijing Education Commission and has extensive contacts with the schools in Beijing. Notices were also sent to professional science & technology teacher associations. Workshop participants applied to attend, and CNIER selected a group.

Buffalo State College (SUNY) has initiated many other collaborative efforts with Universities and other institutions in China. The Buffalo State College Center for China Studies celebrated its ten-year anniversary this past fall (2010). Additionally, Buffalo State College houses a Technology Education program and several Engineering Technology programs.

Workshop Goals and Objectives

The workshop goals were developed collaboratively among CNIER staff and Buffalo State College faculty. Research was conducted by reviewing CNIER Future Engineers materials, Chinese news stories on education, and conducting many interviews. The common over-arching theme was to promote technological literacy in an integrated fashion that is not specific to any existing curriculum, e.g., not a portion of the science or math curriculum.

The workshop goals were to:

- Determine if Chinese teachers can use design as a method of instruction,
- Determine if Chinese teachers would accept design as a method of instruction,
- Present the background of U.S. Technology Education,
- Present an introduction to design as method of instruction,
- Integrate hands-on activities in workshop, and
- Demonstrate an integrated STEM approach.

The presentation of design as a method of instruction included: problem identification & definition, developing a design statement & design brief, research, creative problem solving, selection of a solution, building a prototype, testing & evaluating the solution, and reiteration of the process as necessary. The participants experienced a combination of all these portions of the design process with an emphasis on the "creative act" and "hands-on" participatory learning.

The objectives of the workshop were to:

Objective 1 – Determine if teachers understood how to use design as method of instruction,

Objective 2 - Determine if teachers needed more education to use this method of instruction, Objective 3 – Determine if teachers had the resources needed to use design as a method of instruction,

Objective 4 - Determine if teachers believed the design method could be used to teach creativity,

Objective 5 - Determine if teachers believed they would have the support of their administrators to use this method of instruction,

Objective 6 - Determine if teachers believed this method of instruction could improve student test scores in Math & Science,

Objective 7 – Determine if teachers intended to use design as a method of instruction,

Objective 8 – Determine the level of teachers self assessed (confidence) subject matter expertise for the application of the method of instruction,

Objective 9 – Identify barriers to the use of design as a method of instruction, and

Objective 10 – Determine what resources teachers needed to use design as a method of instruction.

To meet these goals and objectives a workshop plan was created. The plan was to combine lectures and hands on activities. Dr Macho provided the lectures and Michael Bastoni lead the hands-on portions. The intention was to immediately reinforce the ideas presented in the lectures with tactile experiences, and then reflect on those experiences. The content of the lectures were the design methods described in American Society for Engineering Education (ASEE) paper *A Functional K-12 Conceptual Framework for Teaching Technological Literacy* [1]. The hands-on experiences were centered on design challenges using Totally Trebuchet kits from Gears Educational Systems, LLC.

Method

The method of gathering data was a mixed design of quantitative and qualitative measures. The quantitative portion of the survey contained questions which employed five point Likert scales. Qualitative anecdotal evidence was collected as comments on the survey. Each instrument contained open ended questions designed to identify barriers and resources needed the use of the method. The surveys were written in English and translated to Chinese; responses were in Chinese and then translated back into English.

The first of the assessment instrument (survey) was a series of questions intended to gather demographic data. Participants responded to questions about their schools, subject taught, years of teaching experience, and highest degree earned.

The second portion assessment instrument (survey) used a five point Likert scale. Likert questionnaire item data collected were grouped into two sets; pre and post. Each set represents a progression in time and were expected to measure changes. Common metrics were used in the Likert items. Data collected were compared to determine significant differences. Significance was determined by an alpha of 0.05 or less; less than 5% chance of random responses providing the recorded results. The nature of the data collected lent itself to analysis by the use of a General Linear Model (GLM). The method of analysis for the data collected from this workshop was an Analysis of Variance (ANOVA). Appropriate techniques and procedures were observed throughout the analysis.

Findings

Analysis were performed on data collected from 19 participants. Attendees were from Mid School (3%), High School (21%), museum staff members (21%), and others (55%). The "other" category included elementary teachers, publishers, private tutoring services, and various agencies. The participants were technology teachers (24%), science teachers (53%), a math teacher (3%), and others (21%). They reported an average of 13 years of teaching experience. However, a considerable range was reported; expressed by a standard deviation of 10.095. Three participants reported 1 year of teaching experience and at the other extreme two reported more that 40 years of teaching experience. The responses to the question "Highest degree earned were: currently seeking teaching certification (3%), Bachelors in Technology Education (9%), Bachelors (57%), Masters in Technology Education (3%), Masters (6%), and others (23%).

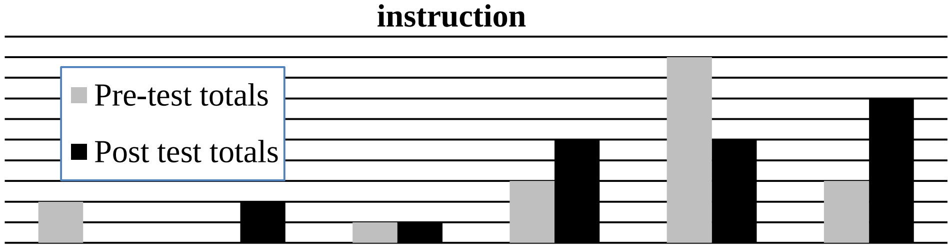
The participants were asked to describe the student gender proportion in their classes. Table 1 *Student gender proportions* illustrates these results. Both technology and science teachers reported a higher number of boys in their classes. While the math teacher reported the ideal gender distribution; that result is unfortunately based upon a single respondent.

Table 1. Student gender proportions

	n	Average proportion of Boys	Average proportion of Girls
Technology teacher	9	71%	29%
Science teacher	20	63%	37%
Math teacher	1	50%	50%
Other teachers	8	58%	43%

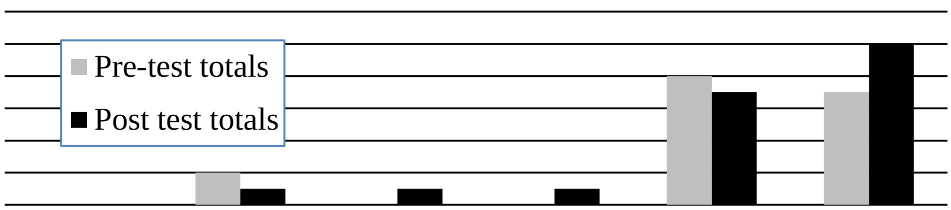
The one-way ANOVA for *I understand how to use design as method of instruction*, contained means of 3.82 for the pre and 3.74 post. These means were not significantly different, $F(1, 34) = 0.050$, $p = 0.817$. *Chart 1. I understand how to use design as method of instruction* appears to illustrates a few more strongly agree they understand how to use design as method of instruction. However, it also appears a few understood it less with 2 strongly disagree responses.

Chart 1. I understand how to use design as method of instruction



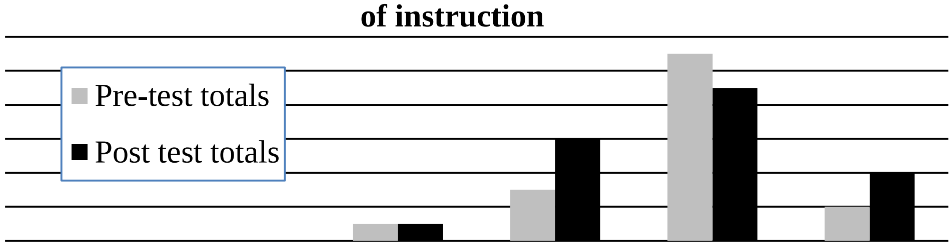
The one-way ANOVA for *I need more education to use this method* contained means of 3.68 for the pre and 4.37 post. These means were not significantly different, $F(1, 36) = 2.645$, $p = 0.113$. *Chart 2. I need more education to use this method* appears to illustrate a need for more education on the use of this method. There also appears to be a few dissenting voices to the trend because there were post workshop respondents who both disagreed and strongly disagreed.

Chart 2. I need more education to use this method



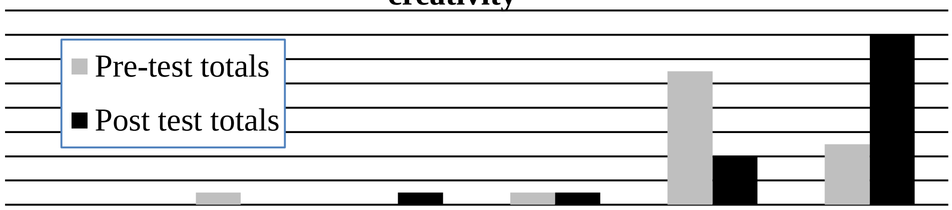
The one-way ANOVA for *I have the resources I need to use design as a method of instruction* contained means of 3.63 for the pre and 3.79 post. These means were not significantly different, $F(1, 36) = 0.240$, $p = 0.627$. *Chart 3. I have the resources I need to use design as a method of instruction* appears to indicate the resources to use the method are already in place. However, this was contradicted by anecdotal evidence.

Chart 3. I have the resources I need to use design as a method of instruction



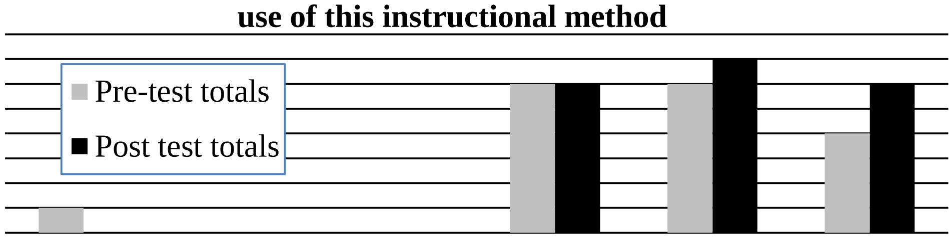
The one-way ANOVA for *I believe the design method could be used to teach creativity* contained means of 4.05 for the pre and 4.58 post. These means were not significantly different, $F(1, 36) = 3.435$, $p = 0.072$. *Chart 4. I believe the design method could be used to teach creativity* illustrates a growing agreement in belief that this method can be used to teach creativity. Given the relatively high pre-workshop rating, it is noteworthy that the result was close to being significantly different.

Chart 4. I believe the design method could be used to teach creativity



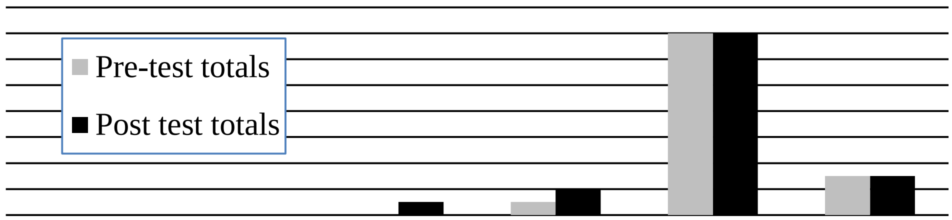
The one-way ANOVA for *my school administrator will support my use of this instructional method* contained means of 3.82 for the pre and 4.06 post. These means were not significantly different, $F(1, 33) = 0.730$, $p = 0.401$. *Chart 5. I believe my school administrator will support my use of this instructional method* illustrates a small change in growing agreement. Interestingly, there were no responses of disagreement.

Chart 5. I believe my school administrator will support my use of this instructional method



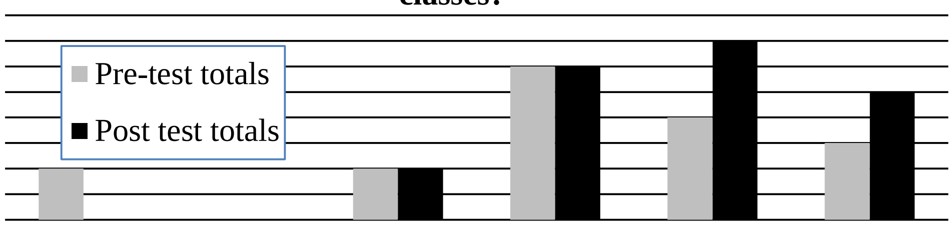
The one-way ANOVA for *I believe this method would improve student test scores in Math & Science* contained means of 4.11 for the pre and 3.95 post. These means were not significantly different, $F(1, 36) = 0.669$, $p = 0.419$. *Chart 6. I believe this method would improve student test scores in Math & Science* illustrates essentially little change; only a change of one from undecided to disagree.

Chart 6. I believe this method would improve student test scores in Math & Science



The one-way ANOVA for *Do you plan to use the design method in your classes* contained means of 3.50 for the pre and 3.79 post. These means were not significantly different, $F(1, 33) = 0.770$, $p = 0.386$. *Chart 7. Do you plan to use the design method in your classes* appear to illustrates an increased intention to use the design method.

Chart 7. Do you plan to use the design method in your classes?



The one-way ANOVA for *Please rate your level of subject matter expertise for this workshop* contained means of 1.63 for the pre and 2.32 post. These means were significantly different, $F(1, 36) = 4.640$, $p = 0.135$. *Chart 8. Please rate your level of subject matter expertise for this workshop* illustrates a change in confidence of subject matter expertise for the workshop.

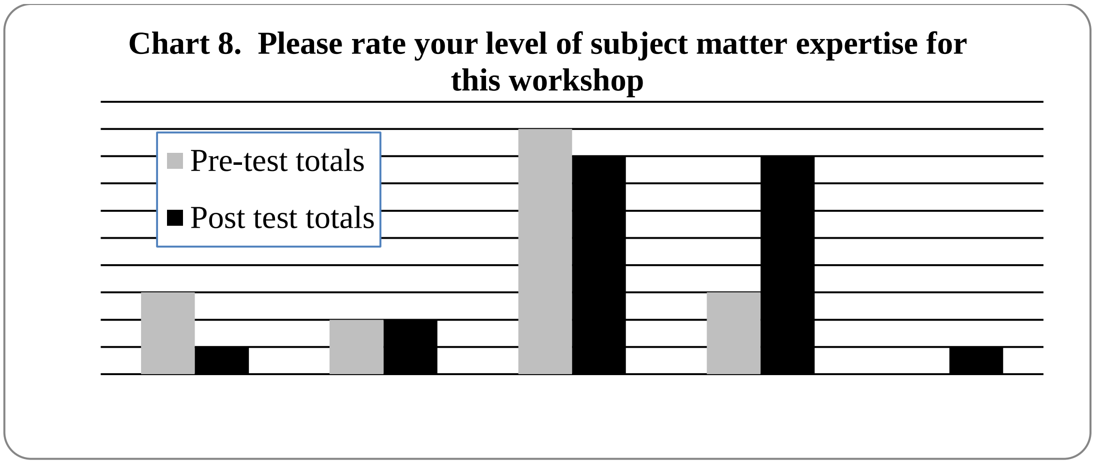


Chart 9. What would prevent you from using a design method of instruction in your school was created from anecdotal evidence derived from the comments written on the survey. The responses to the question were parsed, categorized and counted. The largest change in pre/post responses was in the *time* category, declining from 6 on the pre-survey to 1 on the post survey. Concerns for student abilities (to perform design activities) increased by 2 from pre (1) to post (3). Both Time (6) and Resources (6) were the most common topics written on the pre-survey, however only Resources (5) sustained a large number of comments in the post survey. Professional development was also a common topic in both pre (5) and post (4) surveys. A typical pre-survey comment cited barriers as: "teaching workload, funding, teaching resources." A post-survey comment cited barriers as: "the sense of innovation of teachers and his or her ability to apply the method into effective teaching practice."

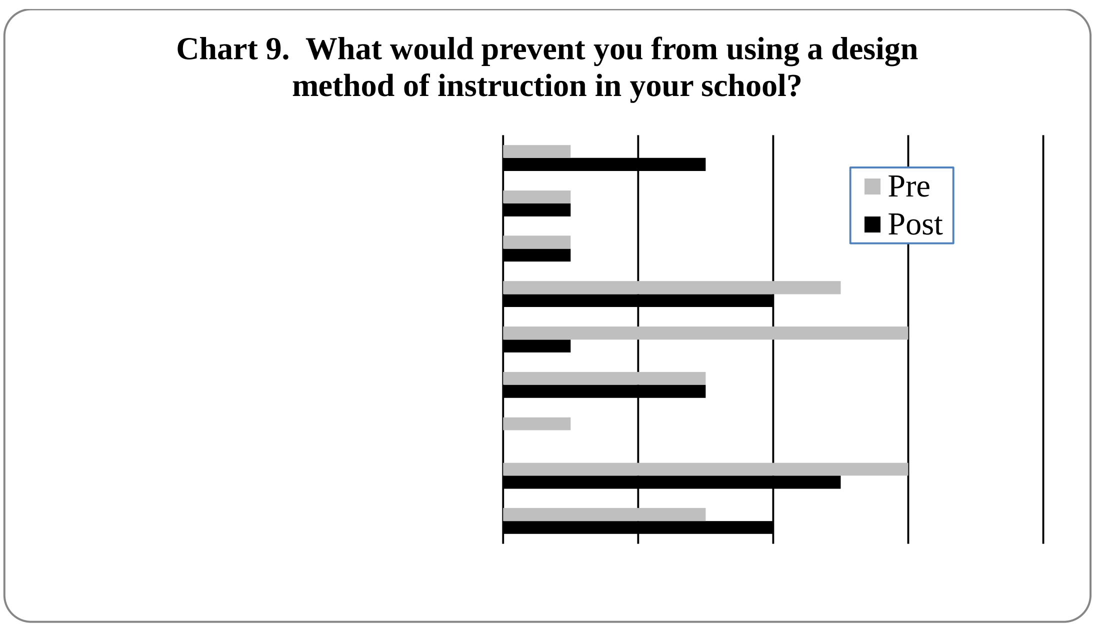
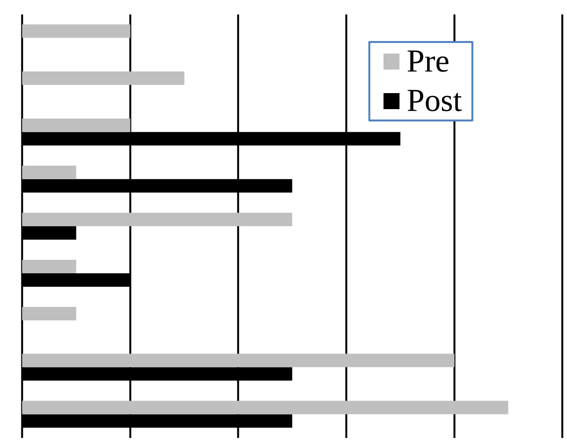


Chart 10. What resources do you need to use design as a method of instruction in your school was created from anecdotal evidence derived from the comments written on the survey. The responses were parsed, categorized and counted. The largest change in pre/post comments was in the category *Lack of instructional materials*; which increased from 2 to 7. This was the

largest change in all comments. The category need for *Professional Development* also increased from 1 to 5

A pre-survey comment cited resources needed as: "relevant materials and book; the learning abilities of the students." A post-survey comment cited needs as: "teaching conventions; facility; systematic theoretical knowledge and professional guidance." Perhaps the most outrageous comment was "If only the national environment could be changed, it is difficult to apply it extensively. Maybe we are not imaginative and not creative."

Chart 10. What resources do you need to use design as a method of instruction in your school?



Conclusions

In demographics, the range of teacher experience was extreme; from newly credentialed teachers to those with exceptionally long and rich careers. As evidenced in Table 1, there seemed to be an unfortunately common gender bias towards males in science and technology.

There was only one significant difference determined by the ANOVA tests; a change in self-assessment of subject matter expertise (perhaps a gain in confidence). Table 2. Summary of Analysis contains the pre-post means and level of ANOVA significance for all the tests. Aside from the one significant result, only the belief that the method could be used to teach creativity was close to being significantly different. However, describing the results reveals tendencies; please note such results should be treated with caution. As a dataset for a pilot study, trends can be viewed as potential tendencies that may deserve further study.

Table 2. Summary of Analysis	Pre mean	Post mean	*P-value*
I understand how to use design as method of instruction?	3.82	3.74	0.817
I need more education to use this method	3.68	4.37	0.113
I have the resources I need to use design as a method of instruction.	3.63	3.79	0.627

I believe the design method could be used to teach creativity	4.05	4.58	0.072
I believe my school administrator will support my use of this instructional method	3.82	4.06	0.401
I believe this method would improve student test scores in Math & Science	4.11	3.95	0.419
Do you plan to use the design method in your classes?	3.50	3.79	0.386
Please rate your level of subject matter expertise for this workshop	1.63	2.32	0.038

In consideration of measures for Objective 1 – *Determine if teachers understood how to use design as method of instruction* -- perhaps this may have been an admission that some *already knew* this method, and the example portrayed in the workshop just proved it to some of the participants. Some teachers had a familiarity with the design process due to participation in Future Engineer and its use in competition. However, the application as pedagogy in regular classroom practice was new. Prior to workshop it was more likely to be encountered in after-school programs; science club, science club, robots, aviation, etcetera. The significant differences measured for Objective 8 – *Determine the level of teachers self assessed (confidence) subject matter expertise for the application of the method of instruction* – also seems to support that some *already knew* this method; and perhaps it was a confidence gain too. However a few respondents seemed to become convinced they understood the method less after the workshop; perhaps the content of the workshop challenged their pre-workshop assumptions.

In the measures of Objective 2 - *Determine if teachers needed more education to use this method of instruction* - there appeared to be a need for more professional development for design as a method of instruction. This was further supported by anecdotal evidence gathered to address Objective 9 – *Identify barriers to the use of design as a method of instruction*, and Objective 10 – *Determine what resources teachers needed to use design as a method of instruction*. Data gathered for Objective 9 cited that professional development was barrier to the used of the method in both pre (5) and post (4) surveys. Data gathered for Objective 10 contained a large gain in requests for professional development; from 1 on the pre to 5 on the post.

Measured results for objective 3 – *Determine if teachers had the resources needed to use design as a method of instruction* –seem to indicate the resources are already in place. However, resources (and facilities) were among the most needed items in anecdotal evidence gathered; second only to instructional resources.

The ANOVA results for objective 4 - *Determine if teachers believed the design method could be used to teach creativity* – were close to significant; p = 0.072. It appeared as a strong trend towards an increased belief that creativity could be taught by the use of this method.

Data gathered for Objective 5 - *Determine if teachers believed they would have the support of their administrators to use this method of instruction* – started with a strongly perceived belief of the support of their school administrators. While the data appears to indicate strong support in the pre-data, and stronger in the post-data, there was not a significant difference.

The pre-post data gathered for objective 6 - *Determine if teachers believed this method of instruction could improve student test scores in Math & Science* – seemed to indicate there was essentially no change in the belief that Math & Science test scores would be affected by the use of this method. The topic of test scores in China is contentious at best. It could well be that the emphasis on test performance and associated established practices to obtain "good" test results contributed to the slight decline in means of pre and post results. The results were mostly in agreement with the notion this method could improve test scores, and it is likely that test score related perceptions of this method would not be a barrier to adoption.

In the data gathered for Objective 7 – *Determine if teachers intended to use design as a method of instruction* - there appeared to be a trend toward an increased application of the method. It is noteworthy, aside from the *not applicable* responses, all participants indicated an intention to use the design method; both pre & post. However, there appears to be a trend of increased intent in frequency of application pre-post.

Anecdotal evidence gathered for Objective 9 – *Identify barriers to the use of design as a method of instruction* – contained interesting and beguiling results. The *time* category posted a dramatic decline in pre-post results; perhaps indicating that time is not as serious of a barrier as perceived prior to the workshop. There were an equal number of results pre-post concerning the teaching environment and context as a barrier. However, the beguiling comment was a perception that "Maybe we (Chinese) are not imaginative and not creative."

Anecdotal evidence gathered for Objective 10 – *Determine what resources teachers needed to use design as a method of instruction* – indicated the need for instructional materials; it was the largest pre-post change in all categories of comments. Other data gathered for this objective has already been presented in the findings of previous objectives.

Implications & Discussion

The development of Chinese students' technology literacy is a stated concern of the Ministry of Education. Design as a method of instruction could substantially contribute to the development of Chinese students' technology literacy given these findings:

- Indeed, Chinese teachers can use design as a method of instruction
- Chinese teachers did accept design as a method of instruction, and they liked it. Generally they thought the method would be useful.
- The significant result in *level of subject matter expertise for this workshop* illustrates a potential change in confidence of subject matter expertise for the workshop. This could be an indicator of a positive result of professional develop. It is difficult to imagine a teacher effectively practicing a method in which they lack confidence.
- Understanding of the method also produced interesting results – leading to the belief the participants "recognized" the method; it was just slightly altered in some *western* way. Some of the participants already use similar processes outside of the "regular" teaching context.
- The near significant difference in the belief the method could be used to teach creativity.

- Little change in belief the method could change math & science test scores – (there was slight decline in means ~ but responses were mostly in agreement already)
- A need for instructional materials for design as a method of instruction was based on anecdotal evidence.
- Time, meaning the length of "class time" may be too short and it is confounded by number of students per class; the typical class size in China is much larger than in the U.S.
- From the prospective of a facilitator of many teacher professional development workshops, it is worth noting that the attendees included many professionals who were not typical public school teachers. There were also cultural and language issues that bore unaccounted effects. This seemed more like a focus group than a typical set of teachers …

Recommendations

In support of the Chinese *National Curriculum Standard for Technology Education for High School*, and to promote the development of students' technology literacy, the following are recommended:

- Replicate the workshop & study with a larger group and longer duration. A one-week workshop during summer of 2011 is in process of being planned. The plan includes follow-up activities during the following holiday to reflect on practice, and identify effective strategies.
- Attempt a truly open ended design experience for teachers; and observe subsequent results with students.
- Seek to establish collaborative teaching efforts with existing teachers and programs that already teach creativity; e.g., bring Art and STEM teachers together to lead students in an open ended design experience.
- Continue to promote international exchange of educators who have experience with the use of design at *all* levels of education (K-20).

Bibliography

1. Macho, S. (2010). American Society for Engineering Education (ASEE): K-12 & Pre-College Engineering Division, AC 2010-2063, and Technological Literacy Constituent Committee, AC 2010-1942: *A Functional K-12 Conceptual Framework for Teaching Technological Literacy*, June 2010. Online @ http://soa.asee.org/paper/conference/paper-view.cfm?id=24492