Journal of Materials Education, Vol. 43 (1-2) : 81-92 (2021)

INFORMED DECISIONS BY ELEMENTARY STUDENTS IN WEB-ASSISTED PROBLEM-BASED LEARNING IN NANOTECHNOLOGY

David Devraj Kumar

STEM Education Laboratory, College of Education, Florida Atlantic University, 3200 College Avenue, Davie, FL 33314

ABSTRACT

Informed decision making is part of critical thinking skills necessary for survival. A retrospective analysis of interview results from a web-assisted Problem-Based Learning (PBL) project in nanotechnology on sunscreen selection involving elementary school students[1, 2] showed the emergence of informed decision making. Most student decisions were based on Risks (e.g., damages to health) and Benefits (e.g., transparent sunscreens) (35.6%), and an understanding of Nano Properties (28.5%), followed by Improve Safety (e.g., impact on health) (10.7%), an understanding of Hands-On (10.7%) nature of science, General (10.7%) feeling of science as "fun," a need to follow Steps in Scientific Methods (8.9%). Society's Needs (7.1%), Solves Society's Problems (7.1%), Need to Consult Alternative Perspectives (3.6%), and Science Work Ethic (3.6%) also have played a part in their decision. Implications for STEM classroom practices, teacher education, and research are discussed.

Key Words: *Decision, Risks, Benefits, Safety, Problem-Based Learning, Web-Assisted, Nanotechnology, STEM, Science*

INTRODUCTION

Insights into informed decisions by elementary students in making an informed choice between sunscreens that contain nanoparticles and those that do not contain nanoparticles in a problem-based learning (PBL) project in nano-technology[1, 2] is reported in this paper. Implications for STEM classroom practices, teacher education and research are discussed. We live in a world heavily influenced by science and it applications in technology. One of the goals of STEM education is develop in children the ability to be critical thinkers, problem solvers and informed decision makers[3, 4, 5]. According to the National Science Teachers Association[3] *Position Statement*, science instruction at the elementary grades should promote in students the ability to make decisions based on evidence.

Decision making is a process that involves weighing all possible options before arriving at a decision and "it helps children to become responsible and independent"[6] (n.p.). The National Science Education Standards[4] in the science content standard, science and technology

standards, and science in personal and social perspectives call for developing in K-12 students decision making skills that include the ability to engage in risk and benefit analysis. Research shows, children as young as toddlers are rational in their decision- making process weighing the costs [or risk] of their actions against the benefits of how much effort they would want to invest in pro-social responding[7]. They posit that "cost-benefit calculations can be traced back to early in life and permeate infants' prosocial responding. Cost-benefit analyses may be fundamental to decision making across a range of contexts and across the developmental trajectory" (pp. 19-20).

Decision Making

The process of decision-making, for example weighing pros and cons, should be nurtured in students in STEM education. The ability to make reasonable decisions develops in children as early as elementary school age[8] and it is a critical component of informed decision making[6]. In science and its technological applications dominated the twenty-first century, it is necessary to cultivate in children the ability to make informed decisions about real-life situations, such as consumer products (e.g., sunscreen, toothpaste), as a matter of personal choice and safety. In a discussion on developing social-emotional skills in children, Darling-Hammond, Flook, Cook-Harvey, Barron, and Osher[9] recommended providing children classroom learning opportunities to identify, reflect and evaluate problems from their individual and societal contexts.

According to the National Survey of Science and Mathematics Education (NSSME+) only 20% of elementary school science classes have emphasized: "Learning about real-life applications of science/engineering" and 29% "project-based learning" (PBL)[10]. In practice, both problem-based learning and project-based learning are aimed at developing metacognitive skills by engaging students in tackling and solving authentic tasks connected to real-world situations, though critics might differ. STEM learning experiences in elementary schools should engage students in PBL activities that enable them to connect classroom STEM lessons to their daily lives. For example. the field of nanotechnology is enriched with real-life STEM applications of nanoscale materials such as sunscreens with nanomaterials, light-emitting diodes (LED), and water repellent khaki in society that students are easily able to connect.

Education Involving Nanoscale Materials

Integrating nanoscale materials education into STEM is a growing trend in K-12 . Education involving nanoscale materials ranges anywhere from studying the science of matter at the nanoscale, simulating scaling and measurement activities also called nanometry education[19], and exploring the real-world applications of nanoscale science in technologies. When matter is dealt within the nanometer range, which is one-billionth of a meter in size, it exhibits numerous optical, electrical, chemical, and magnetic properties attributed to quantum effects that are quite counterintuitive to those displayed by matter in macro or bulk scale. For example, regular zinc oxide appears white because light waves upon impact get scattered. On the other hand nano zinc oxide is small enough to allow light waves to pass through; hence sunscreens with nano zinc oxides appear colorless. This counterintuitive phenomenon, because of unusual properties of matter at the nanometer scale is a unique opportunity for gaining attention, especially in the elementary grades where students need innovative ways to motivate them to think about the science they learn through observable properties.

As noted above, nano zinc oxide is used in a wide range of consumer products including certain brands of sunscreens making education involving nanoscale materials meaningful and appropriate for science lessons. It is no wonder why the National Nanotechnology Infrastructure Network[11] proposed introducing nanotechnology in K-12 school science. Nanotechnology helps to provide educationally meaningful connections to health, environment, energy, and societal issues suitable for K-12 classrooms. In this context a description of the web-assisted PBL in

nanotechnology project[2] retrospectively analyzed follows. The purpose of the analysis is to gain insights into decision-making by fifth-grade elementary students involving sunscreens with and without nanomaterials through a web-assisted problem based learning project in nanotechnology.

PROBLEM-BASED LEARNING (PBL)

Problem-Based Learning (PBL) is a goal oriented educational strategy to promote student learning in the context of complex real-world problem situations to develop critical thinking, problem solving and communication skills[13]. PBL emerged over several decades from the design of small-group, student-centered, curriculum for medical students around problems that they could relate to in the real world. PBL lessons are introduced through learning cycles (e.g., The STAR Legacy Learning Cycle, discussed in detail under separate heading in this paper). Research on PBL among medical students indicate that students in PBL programs achieve as well as students in traditional programs on traditional exams[20]. Student oriented advantages of problem-based learning include active learning, critical thinking, flexible reflections, and fruitful group cooperation[21].

The essential components of problem-based learning are loosely structured learning cases developed on a multimedia platform, student-centered learning, and small-group cooperative learning[22]. The classroom teacher' becomes a facilitator of self-directed learning among students. "Students pursue their own problem solutions by clarifying a problem, posing necessary questions, researching these questions, and producing a product that displays their thinking. These activities are generally conducted in collaborative learning groups that often solve the same problem in different ways and arrive at different answers"[23](p. 50). Using multimedia platforms to anchor problem-based learning in a context often enriched with all the data necessary for solving problems is known as Anchored Instruction[13]. In the project represented in this study multimedia anchors for PBL were developed on a WWW platform, hence called web-anchored PBL.

Web-Assisted PBL in STEM with Nanoscale Materials

In a web-assisted problem-based learning (PBL) in STEM education through nanoscale materials project, the *PBL Nanotechnology*, three web-assisted STEM modules (Catching the Rays, Friend or Foe, Going Green) were developed and field-tested. See Kumar and Yurick[2], and Kumar[12] for details. Web-assisted PBL deals with problem-solving in a real-world context augmented with web-assisted instructional resources (e.g., episodes) to cultivate higher-order thinking and problem-solving skills in students essential to making informed decisions. The theoretical basis for this approach is founded upon situated cognition and its applications in videos; the Anchored Instruction[13] centered around video based enriched contexts and delivered through an engaging lesson cycle called the STAR Legacy Learning Cycle[14] to engage students in realistic complex problem solving, and associated transfer, reflection and critical thinking skills (Figure 1).

The Software Technology for Action and Reflection (STAR) Legacy Learning Cycle

The STAR Legacy Learning Cycle[14] is a five-step learning process built on learning theories such as cognitive learning theory and situated cognition[13, 24], to guide the teacher and students through a PBL activity, in this study the Catching the Rays multimedia module involving sunscreen selection[2, 12]. A narrator in the multimedia navigates the teacher and students through the module by providing cue to research, reflect, pause/stop for brainstorming ideas, testing students ideas, etc. The first step in the Legacy Cycle is the "Challenge" where, the narrator introduces the teacher, who presents students with a challenge to research sunscreens containing nanoparticles and regular sunscreens and make an informed decision which one to purchase based on their research.

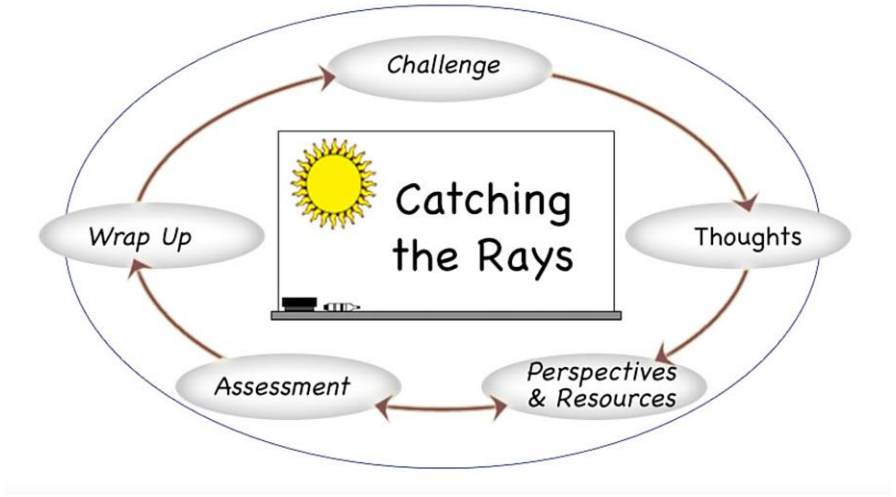

Figure 1. Modified STAR Legacy Learning Cycle

In the second step in the Legacy Cycle, the "Initial Thoughts," the teacher invites students to reflect collaboratively on the key words within the challenge statement to start an initial thoughts discussion. The teacher also introduces a set of questions for students to think about, for example, How does sunscreen protect us from UV rays? What are nanoparticles? These questions are also made available on the Resources section of the module. The, students are asked to pause the module to complete an Initial Thoughts organizer. When the module resumes, students share their organizer with the class.

The third step in the Legacy Cycle is "Perspectives and Research," where the narrator invites students to research the Internet to develop a conceptual understanding of nano particle and sunscreens. The teacher encourages students to consider various perspectives throughout their research process. Besides Internet research, and consulting reference sources of basic information, students are invited to conduct some research of their own. Procedure for a sunscreen experiment using UV detecting beads is made available on the Resources link.

During the fourth step in the Legacy Cycle "Assessment," students are asked to reflect on the conceptual understanding they developed during the Perspectives and Research step, and test their understanding by responding to the set of questions posed by the teacher in the Initial Thoughts step. It involves assessing by trial and field testing, providing feedback and refining strategies. The teacher reminds students that revisits to the Perspectives and Research step are part of the learning cycle.

The fifth and the final step in the Learning Cycle is "Wrap Up," where the teacher stresses the importance of scientists to share the findings based on the information they gathered with colleagues. Students are invited to prepare their presentation, to select a forum for presentation, and share their informed decisions based on the scientific evidence from both their Internet research and sunscreen UV bead research to support their decision.

Through the sunscreen activity with UV beads students gained a general understanding that both sunscreens blocked UV light to various degrees[1, 2, 12]. The Catching the Rays module is aligned with the National Science Education Standards [4], and closed-captioned for hearing challenged students.

The 'Catching the Rays' module was pilot tested along with the Going Green and Friend or Foe among elementary students[1, 12] for Science

Conceptual Understanding (SCU). Based on the findings, it was field tested for Quality of Student Learning in Science, conceptualized into Science Conceptual Understanding (SCU), Attitude Towards Science (ATS), and Perception of Science in Society (PSS) using pre- and post-tests and post-interviews. The sample was elementary (grade 5) students (N = 46) in a school located in the southeastern part of the United States. Students in the school were assigned to the school by the respective school board on demographic factors. About one-fourth of the students in the school were classified as Students with Disabilities and about half on Free and Reduced Priced Lunch. The SCU pre-and post-tests showed a significant gain (Paired $t = -16.27$; $df = 45$; $p < 0.01$). The ATS pre-and post-tests resulted in significant gain (Paired $t = -2.52$; $df = 45$; $p < 0.01$). A systematically chosen sample (N=6) of participating students was interviewed to probe further in terms of their PS in addition to SCU and ATS.

METHOD

A retrospective analysis of interview data from the Problem-Based Learning with nano-technology project[1, 2]on sunscreen selection "Catching the Rays" was undertaken looking for emerging themes dealing with informed decision making by elementary students. The purpose was to gain a more in depth understanding student decisions with respect to all Quality of Science Learning categories - Science Conceptual Understanding (SCU), Attitude Towards Science (ATS), and Perception of Science in Society (PSS) - and Learning Gain (LG) groups.

Analysis of Interview Data

The data for the retrospective analysis was the post-interview data from the "Catching the Rays" sunscreen selection module[2]. A Learning Gain point system was used for purposeful selection of post-interview participants.

Learning Gain (LG) is operationally defined as the learning gained by students at two points or the difference between the student's performance score on a test (e.g., achievement, conceptual understanding, etc.) the first time (pre-test) and a second time (post-test)[25, 26, 27, 28].

LG = (post-test score) – (pre-test score). "Learning Gain" calculations are used in student test analyses from elementary through college education[26, 27]. In the data retrospectively analyzed, Learning Gain (LG) is the difference between students' raw Science Conceptual Understanding pre- and post-test raw score. Based on the LG scores, students were divided into the following groups. The Large Gain (LG) group had a point range of 5 (+12 to +17) and 10 subjects. The point range for Medium Gain (MG) group was 4 (+8 to +11) and 25 subjects. The Little to No Gain (LTNG) group had a point range of 6 (+1 to +7) and 11 subjects. Two subjects were randomly selected from each group for the post-interview. This purposive approach to sampling with the objective to gain in-depth insight into the thoughts of a very small number of subjects across learning gain spectrum is based on recommendations by Miles and Huberman[15] and Merriam[16] in situations involving limited pool of subjects. Considering the importance of conceptual understanding of nanoscale materials in decisions concerning sunscreens with and without nanoscale materials, interview questions 1 and 3 (Table 1) with closed ended responses were included in the retrospective analysis. The analysis proceeded with coding and constant comparison of student post-interview responses, looking for emerging themes. An intercoder reliability check of emerging themes reached 90% agreement.

RESULTS

Analysis of the post-interview responses resulted in emerging themes under all Quality of Science Learning categories (SCU, ATS, PSS). Post-interview questions, sample phrases from student positive responses, and emerging themes follow (See Table 1).

Table 1. Emerging themes across responses by Interview Questions[1, 2]

Interview Question (SCU/ATS/PSS*)	Sample Student Response (positive)	Emerging Theme
1. Arrange the following three items from smallest to largest; Ant, Head of a pin, nano zinc oxide. (SCU)	"nano zinc oxide, head of a pin, ant" (LG subject)	Nano Properties
2. What did your energy bead activity teach you about sunscreens containing nanoparticles and regular sunscreen? (SCU)	"…nano can get into your bloodstream." (MG student) "But some people have skin problems and are worried nano can get into your bloodstream." (MG student)	Risks and Benefits
	"…nanoparticles [sunscreens] are clear … and they protect better. Regular sunscreen scatter, are white and bulky…" (LG student) "The nano energy bead activity taught me nano protects better because it absorbs and it is clear. The regular sunscreen scatters and it's white." (MG student)	Nano Properties
3. A nanometer is about 1,000 times smaller than the size of your classroom, your neighborhood, an ant or a football field. (SCU)	"an ant" (LG student)	Nano Properties
4. What did Catching the Rays teach you about learning science? (SCU)	"Catching the Rays taught me the learning cycle which is a hard challenge so you start with first you do research, perspectives and then you get a recommendation and you're done."(MG Student)	Steps in Scientific Method
	"You can't just jump in." (LG student)	Science Work Ethic
5. Is the nanotechnology in sunscreen risk free? Explain. (SCU)	"It may get into the bloodstream." (LTNG student) "It might affect the problem they have with their skin." (MG student)	Risks and Benefits
	"I would recommend asking your doctor first before using nano sunscreen." (LTNG Student)	Consult Alternative Perspective
6. How do you feel about science compared to other school subjects? Explain using class examples. (ATS)	"…you can actually conduct experiment… . It's fun like when you do projects on say when you do projects on UV beads like we did in this lesson" (MG Student) "..involves more experiments..." (LTNG student)	Hands-On
	"Science is fun." (LG student) "I think everyone should learn science." (MG student) "I think math and science is [sic] really good when it comes with working things out together" (LTNG student)	General
7. Would you recommend nano sunscreen or regular sunscreen to your neighborhood community? Explain. (PSS)	"Nano sunscreen because it protects better but some people shouldn't use it." (MG Student) "I would recommend nanosunscreen but I would also have concerns. There also are concerns because for people with skin problems regular sunscreen would be better. Because sunscreens with nanoparticles are small enough to go through cracks or openings in your skin that can go into your bloodstream." (LG student)	Risks and Benefits
8. Sunscreen existed before nanotechnology so why do you think scientists care about changing the ingredients of sunscreen?	"…it might help protect more." (LTNG Student)	Improve Safety

(PSS)		
9. Do you think Nanotechnology can help solve people's problems in other ways? Explain. (PSS)	"Yes. Consumers like nanosunscreen because it is clear and it protects their skin more again if you do not have skin conditions. Yes. Scientists are using nanotechnology as tools in the medical industry to help patients with other medical conditions using little nanorobots they put the robot into the body and it travels through the bloodstream to the parts inside the body." (LTNG Student)	Society's Needs Risks and Benefits
10. Do you think there is a relationship between sunscreen manufacturers, nanotechnology and people? Explain. (PSS)	"Yes, there is a connection because the manufactures since they need products to keep peoples skin to getting more tan and cancer they made nano and that relates to people to help them and keep them safe." (LG Student)	Solves Society's Problems

Note: (*) Quality of Science Learning category.

Table 2. Matrix of emerging themes and learning gain groups

Emerging Theme	**Prompting Question**	**Quality of Science Learning (SCU, ATS, PSS)**	**Occurrence by Learning Gain Group**			**Emerging Theme Total**	**Emerging Theme Percent**
			LG (n=2)	**MG (n=2)**	**LTNG (n=2)**		
Risks and Benefits	#5	SCU	2	2	2	6	10.7
Risks and Benefits	#2	SCU	2	2	1	5	8.9
Risks and Benefits	#7	PSS	2	2	1	5	8.9
Risks and Benefits	#9	PSS	2	1	1	4	7.1
Nano Properties	#1	SCU	2	2	1	5	8.9
Nano Properties	#2	SCU	2	1	2	5	8.9
Nano Properties	#3	SCU	2	2	2	6	10.7
Improve Safety	#8	PSS	2	2	2	6	10.7
Hands-On	#6	ATS	2	2	2	6	10.7
General	#6	ATS	2	2	2	6	10.7
Steps in Scientific Method	#4	SCU	2	1	2	5	8.9
Society's Needs	#9	PSS	2	1	1	4	7.1
Solves Society's Problems	#10	PSS	2	1	1	4	7.1
Consult Alternative Perspectives	#5	SCU	0	1	1	2	3.6
Science Work Ethic	#4	SCU	1	1	0	2	3.6

Note: Total exceeded 100% due to multiple emerging themes from Question 9.

A review of emerging themes shows the Risks and Benefits theme emerged from student responses to Questions 2 (SCU) and 5 (SCU), Question 7 (PSS) and part of Question 9 (PSS) under Quality of Science Learning categories total 20 times (35.6%) (Table 2). A note should be made that the question 5 "Is the nanotechnology in sunscreen risk free? Explain" received responses from all three learning gain groups. Sample Response - "It might affect the problem they have with their skin" (MG Student) (p. 59). Though this was previously categorized as "Medical Risk" as it represented Risk, it could be included in the "Risks and Benefits" category. Contributing learning gain groups for Risks and Benefits theme are LG 100%, MG 87.5% and

LTNG 62.5%.

The theme Nano Properties emerged from student responses to Questions 1 (SCU), 2 (SCU) and 3 (SCU) total 16 times (28.5%). Contributing learning gain groups are LG 100%, MG 83.3% and LTNG 83.3%.

The Improve Safety theme emerged from student responses to Question 8 (PSS), and the Hands-On theme and the General theme from responses to Question 6 (ATS) emerged a total 6 times (10.7%) each with 100% representation from LG, MG, LTNG learning gain groups. The Steps in Scientific Method emerged 5 times (8.9%) from responses to Question 4 (SCU) with 100% LG, 50% MG and 100% LTNG contributions from learning gain groups.

The themes Solves Society's Problems emerged 4 times (7.1%) from student responses to Questions 10 (PSS). Learning gain groups represented are LG 100%, and MG and LTNG 50% each. The Society's Needs theme emerged 4 times (7.1%) in responses to Questions 9 (PSS) from learning gain groups LG 100%, and MG and LTNG 50% each. As noted earlier, this response also generated the theme Risks and Benefits.

The Consult Alternative Perspective theme emerged from student responses to interview Questions 5 (SCU) 2 times (3.6%) represented by LG 0%, and MG and LTNG 50% each. The theme Science Work Ethic theme emerged from Question 4 (SCU) 2 times (3.6%) from 50% LG, 50% MG and 0% LTNG learning gain groups.

DISCUSSION

The results of this retrospective analysis of interview data from the web-asssited PBL nanotechnology project is limited to fifth grade elementary students in a public school in the southeastern United States. The reader should consider how to apply the findings in other similar contexts.

The results clearly show the emergence of informed decisions by elementary students about sunscreen selection. Student decisions involved mostly weighing the Risks and Benefits of sunscreens containing nanoscale (zinc oxide) materials versus regular (zinc oxide) materials, with an understanding that though they bring benefits to society they also come with risks especially associated with health. The Risks and Benefits theme is considered a significant informed decision making skill[4, 6, 7, 8]. Students have weighed in risk and benefits, taken into consideration if the technology would solve society's problems and improve safety in terms of society's needs.

The Risks and Benefits theme emerged the most 35.6% from the Science Conceptual Understanding and Perception of Science in Society Quality of Science Learning categories. It is worth noting a sample response from a LTNG Student - "Yes. Consumers like nanosunscreen because it is clear and it protects their skin more again if you do not have skin conditions. Yes. Scientists are using nanotechnology as tools in the medical industry to help patients with other medical conditions using little nanorobots they put the robot into the body and it travels through the bloodstream to the parts inside the body." In order to make informed decision on Risks and Benefit concerning products involving nanomaterials, an understanding of nano properties is critical and the Nano Properties theme emerged the second, 28.5% from SCU. Further discussion will address the themes in descending order they emerged.

The Improve Safety theme, another important criteria in sunscreen selection involving nanoparticles is represented in full by all three learning gain groups. It is interesting to note that students across all three learning gain groups have taken into consideration safety as a factor in their decision making process in selecting between sunscreens containing nanoscale zinc oxide particles and those containing regular zinc oxide particles. An understanding of Perception of Science in Society is elementary to think about safety of a consumer product.

It is worth noticing that the Hands On theme and the General theme have emerged from the Attitude Towards Science category representing all three learning gain groups in full. Sample student response from Hands-On theme – "It's fun like when you do projects on say when you do projects on UV beads like we did in this lesson…" (MG Student). A sample response from the General theme - "Science is fun." (LG Student). The effect of the hands-on activity in the web-assisted PBL nanotechnology Catching the Rays module if any and the general positive affective effects if any in learning with the module are worth exploring in future studies.

Complementing the two themes Hands-On and General, the theme Steps in Scientific Method emerged 5 times (8.9%) from responses to Question 4 (SCU) with 100% LG, 50% MG and 100% LTNG contributions from learning gain groups. It is worth noting a sample response from a MG student contributing to the Steps in Scientific Method theme - "..first you do research, perspectives and then you get a recommendation and your'e done." However, a 50% drop in positive responses from the MG group is worth exploring in further studies.

Other emerging themes worth noticing are as follows. The theme Society's Needs and the theme Solves Society's Problems representing all LG and half of MG and LTNG learning gain could be inferred that the students had a reasonable Perception of Science in Society in their decisions about sunscreens with and without nanoparticles. The theme Consult Alternative Perspectives has no contributions from the LG learning gain group and half from MG and LTNG groups. A sample response from a LTNG Student - "I would recommend asking your doctor first before using nanosunscreen." Finally, the theme Science Work Ethic has no representation from LTNG group, and only half each from LG and MG learning gain groups. Here is a sample response from a LG Student - "You can't just jump in." Lack of any positive response from LTNG group is worth exploring further.

SUMMARY AND IMPLICATIONS

Emergence of informed decisions by elementary students about sunscreen selection in their decisions weighing the Risks and Benefits, their understanding of Nano Properties complemented by several factors such as Improve Safety, Steps in Scientific Methods, Hands-On, etc., in varying degrees representing Science Conceptual Understanding, Attitude Towards Science and Perception of Science in Society is evident in the analysis. In this context implications for STEM classroom practices, teacher education and research follow.

Classroom practices in terms of instructional strategies and student learning styles vary considerably within and across STEM disciplines, grade levels and classrooms. According to NSSME[10] less than 53% elementary school science classes offer hands-on learning experiences though 93% elementary school teachers agree that when instruction is connected to students' everyday lives, they learn the best[8]. The web-assisted PBL module provides real world connections by virtue of its design involving the Legacy Learning Cycle and video anchors, and seem to promote decision making skills.

Teachers are key to classroom reform. Science teacher education should provide prospective teachers with appropriate opportunities to discuss and develop cognitively engaging and motivating methods of teaching nanoscale science with particular attention to informed decisions involving products containing nanoscale materials. Classroom teachers need suitable curriculum resources to facilitate the implementation of teaching and learning nanoscale science. Both the pre-service teacher education curriculum and in-service teacher development programs should address teaching methods and learning skills involving nanoscale materials, and the role of teacher education faculty, local school administrators and policy makers on this task is significant.

Students making informed decisions in learning

environments involving web-assisted Problem-Based Learning with nanoscale materials is an emerging area needing further research. This area of education needs answers in terms of the effect of subject matter, grade level and demographics on student learning. Suitable, authentic assessment items in PBL, valid enough to replace often culturally skewed traditional standardized tests that are biased against certain minority groups[17] should also be researched and developed. This is particularly important for promoting diversity and inclusion and to make STEM available for all students. As *Project* 2061[18] (American Association for the Advancement of Science (1990) proposed science [STEM] is for "All Americans." To facilitate STEM education for all students, web-assisted Problem-Based Learning with nanoscale materials should not be limited to elementary grades, but should be extended to middle and secondary grades. Informed decision making, an important skill very much needed for survival in the twenty-first century influenced by science and technology should be promoted at all grade levels.

ACKNOWLEDGEMENTS

Thanks to John Harwood for assistance with Figure 1. The web-assisted PBL nanotechnology unit discussed in this paper is part of the *PBL Nanotechnology* project[1] developed and field tested with funding from the Ewing Marion Kauffman Foundation. Views expressed are not that of the funding agency. Portions of Table 1 are adapted from Kumar and Yurick[2] and used with permission.

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ADDENDUM

GLOSSARY OF ACRONYMS

ATS	Attitude Towards Science
LG	Learning Gain/Large Gain
LTNG	Little-to-No-Gain
MG	Moderate Gain
PBL	Problem-Based Learning
PSS	Perception of Science in Society
SCU	Science Conceptual Understanding
STAR	Software Technology for Action and Reflection
STEM	Science, Technology, Engineering and Mathematics
UV	Ultra Violet
WWW	World Wide Web

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