Working Group #6: Rich Learning Tasks

Leaders

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History of Working Group

This is the 5th meeting of the Rich Learning Task working group. Previous meetings: Australia (Palm Cove, Queensland) 2001; Italy (Terrasini, Palermo, Sicily) 2002; Czech Republic (Brno) 2003; Malaysia (Johor Baru) 2005

Introducing the Two Learning Games and Rich Learning Tasks

(From Gary's paper.) The classroom can be thought of as an arena in which 'the learning game' is played. At first glance, there would appear to be myriad variations of this game. When stripped to their essentials, however, the number of learning games reduces to two. I label one, 'the knowledge game', the other, 'the sense-making game'. These two learning games are quite different in character and purpose. They make different demands on the players. They are governed by different rules. They have different goals. They foster and reinforce different dispositions, habits, and beliefs in the players. (Of course, there are knowledge and sense-making components in both games. However, knowledge is acquired and used very differently in the two games and the purpose, nature, quality, and quantity of the sense-making is also very different in the two games.) *In addition, the habits, and dispositions fostered by one game act as impediments to playing the other game.* I then go on to say, *Played well, both learning games can prepare players for success in school. However, only the sense-making game prepares players for life beyond the classroom. Unfortunately, …. the knowledge game is the learning game played most frequently, in most classrooms.*

Rich Learning Tasks require and foster the playing of the Sense-Making Game.

A (Brief) Description of the Two Learning Games

The Sense-Making Game involves such things as:	*The Knowledge Game* involves such things as:
- action (sense-making action) - teaching for understanding - education not inculcation - learning with understanding - making sense of / with concepts and procedures - making sense of situations - using knowledge in an integrated, authentic, and purposeful fashion - using one's imagination and intuition / indulging one's curiosity - making sense to / of others - learning / using / refining sense-making procedures - inquiring / investigating / experimenting - thinking critically - problem solving / problem posing - developing dispositions / attitudes / habits of mind / beliefs of a sense-maker - engaging rich learning tasks	- acquisition (of knowledge) - transmitting / reproducing information - inculcation not education - selecting appropriate rules / facts - duplicating procedures / adhering to conventions - knowing 'how' to do things - mimicking others - memorizing - answering speedily / accurately - technical proficiency - developing dispositions / attitudes / habits of mind / beliefs of a knowledgeable person - engaging routine or (at best) pseudo-rich learning tasks
Playing the Sense-Making Game feels like a trip into the Wild.	Playing the Knowledge Game feels like a trip to the Zoo.

A Generic Framework for Understanding Either Learning Game

Students and teachers will not (and cannot) play either learning game unless they are willing to play it, unless they have the opportunity to play it, and unless they have the means or wherewithal to play it. The following generic 3-part framework (for reflecting on the two learning games) is based on these '*three essential conditions for playing a learning game*.' Factors that have a major influence on each of these three conditions are included in the framework. Any discussion of learning games that doesn't take all three of these conditions into consideration is incomplete. Learning activities or initiatives that don't take all three of these conditions into consideration usually prove to be ineffective, usually founder.

The following framework should be interpreted from (at least) two perspectives, the student's and the teacher's.

FRAMEWORK

1. The Player's Desire / Willingness to Play the Chosen Learning Game
(a) player's *history of learning experiences*
(b) player's *learning / classroom environment*
(c) player's *values*
(d) player's *dispositions / attitudes*
(e) player's *expectations*; *beliefs about / sense of self and other players*
(f) player's *beliefs about / sense of the discipline*
(g) player's *motivation / incentives / rewards*

2. The Player's Opportunity to Play the Chosen Learning Game
(a) *the learning/ classroom environment*
(b) *learning tasks*
(c) *interaction amongst players*

3. The Player's Ability / Wherewithal to Play the Chosen Learning Game
(a) *prior knowledge*
(b) *previous learning experiences*
(c) *inclinations*
(d) *thinking / learning habits*
(e) teaching practices / tools to facilitate learning

Sample Questions Arising From Plenary Sessions and WG#6 Papers

1. Douglas Butler: Opening Plenary Saturday 09:00 *We've Got All These Gadgets. Now What?* Doug talks of the *modern classroom* filled with gadgets that are useless unless the teacher is trained in the use of these gadgets.
Q. Will training teachers in the use of 21st century gadgets encourage teachers and students to play the sense-making game?

2. Brad Hanson-Smith: Saturday 14:00 *What is the future of Wholemovement in the development of Mathematics Education? asked the question*
Q. Would we be able to recognize the wild if we saw it? / Would we recognize a potentially rich situation if we saw it?

3. Anna Baccaglini-Frank: Saturday 14:45 The CME Project, looking at sample of writing and hearing about the influence of the publisher on the process
Q. How can tasks be restructured to make them richer? (eg Q6-8)

4. Tony Shannon: Saturday 16:00 Creative *Thinking in Problem Solving* said 'We can gear learning experiences to facilitate creative thinking.'
Q a) How can we gear learning experiences to facilitate creative thinking?
Q b) How can we gear teachers to gear learning experiences to facilitate creative thinking?

5. Alan Russell: Saturday 16:30 …*Paper Folding in Mathematics Education* asked Why is this (origami) task rich? And answered 'because it is an authentic task.'
Q. Does an authentic task suggest a rich task?

6. Nat Friedmann: Saturday 17:15 *Knots and Soap Film Minimum Surfaces* Was Nat in the wilds of knot theory?
Q. What are some characteristic actions of a teacher (or student) functioning in the wild?

7. Fernando de la Cueva Landa Sunday 11:30 *Workshop of Mathematical Talent* pointed out a silver-medal winning math Olympiad student in one of his slides.
Q. Do Math Olympiads and the like represent the apex of Knowledge games?

8. Linda Schofield: Sunday 12:15 *Project M^3:Mentoring Mathematical Minds* mentioned journals, hint cards, adding depth and complexity to tasks
Q a) Are there 'hint' cards in the wild? (and if so, what form might they take?)
Q b) Is there a difference in the ways in a task is made deeper and more complex when the Knowledge Game is being played compared to when the Sense-Making Game is being played?

9. Mark Ellis & Carol Malloy Sunday 14:00 *Preparing Teachers for Democratic Mathematics Education*
Q a) Is the Knowledge Game essentially undemocratic?
Q b) Is the Sense-Making Game democracy in action?

10. Mark Applebaum: Sunday 14:30 *Translations Toward Connected Mathematics*, involved us with different problems that made use of the same method. Recall also that Linda Schofield talked about "the end of a problem not being the end of the problem."
Q. When is the end of a problem the end of the problem?

11. Bernard Camou: Sunday 15:15 TEP Tackling Epistemological Problems, took us through a workshop dealing with regular polyhedra, talking about things like multi-representations. He said in part that …
Q. 'The obvious problem is to solve problems'. Is that the obvious problem?

12. Gideon Weinstein: Sunday 16:30 *Frameworks for Improving Mathematical Sophistication and Teaching Philosophies talked* about staged improvement of teachers.
Q. Does a move from the Knowledge Game to the Sense-Making Game require an evolutionary or revolutionary approach to change?

13. Hugo Rodriguez: Sunday 17:00 *Fractions Without Pain*
Q. How great is the risk that manipulatives will be used in a directed / lock-step fashion?

14. Hank Kepner: Tuesday 09:ish, *a brief review of 'mathematical proficiency'*

Mathematical Proficiency: five strands: (p 5)

- *conceptual understanding* – comprehension of mathematical concepts, operations, and relations
- *procedural fluency* – skill in carrying out procedures flexibly, accurately, efficiently, and appropriately
- *strategic competence* – ability to formulate, represent, and solve mathematical problems
- *adaptive reasoning* – capacity for logical thought, reflection, explanation, and justification
- *productive disposition* – habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy.

(from *Adding it up: Helping children learn mathematics.* J. Kilpatrick, J. Swafford, and B. Findell (Eds.). Mathematics Learning Study Committee, Center for Education, Division of Behavioral Sciences and Education. Washington, DC: National Academy Press.)

Q a) Consider the National Research Council's description of 'mathematical proficiency'. What are the implications for the kind of learning game played in the classroom?

Q b) Can you become 'mathematically proficient' playing the Knowledge Game?

Q c) Is there more to 'mathematically proficiency' than that put forward by the NRC? Here are my thoughts about our working group.

Tuesday's Discussion

Though all of the above questions are linked, the group decided to focus discussion on two questions.

The first question (we called it Question #0) arose from our first session on Saturday. It arose from Gary's review of previous meetings, a brief description of Rich Learning Tasks, a brief review of the Sense-Making Game and the Knowledge Game, and a brief description of the metaphors of 'mathematics in the wild' and 'mathematics in a zoo'. Why separate knowledge and sense-making? Why the binary? [The separation of knowledge and sense-making proved illusory. Sense-making makes uses of knowledge and generates knowledge. There is sense-making, knowledge use, and knowledge generation in both learning games. But, the way in which knowledge is used and the quality of the knowledge generated are very different in the two learning games. So too are the inclinations, beliefs, skills, and habits fostered in players by each game very different. What it means to be a student (or a teacher), what their 'work' is, is very different in the two games. They are different in ways that are similar to the ways in which a trip to the zoo differs from a trip into the wild.]

The second question arose from Gideon Weinstein's presentation and the idea of staged improvements of teachers' mathematical sophistication and mathematics teaching philosophy. Can change from the Knowledge Game to the Sense-Making game be evolutionary or must it be revolutionary? Can the change be incremental or is a clean break from past practice required?

Reflections from Some Working Group #6 Participants

It is quite difficult to capture the flavor / intensity / depth of the discussion in the group over the three days. It was felt that some of it could be captured by inviting 'hardcore' participants to add some of their post-meeting thoughts / reflections to this report. Brad, Bron, Gideon, Glenn, Linda, and Gary took up the invitation. They are presented, verbatim, below.

a) Reflection by Bradford Hansen-Smith

After presentations of various approaches to engaging students in more participatory or "authentic" mathematical experiences, and necessary assessment strategies, there was much discussion about the difference between "sense making" and the "knowledge game"; to be locked in the "Zoo" with specimens of understanding to be learned in the same way, and the different of open capacity to function in the "wilds" where we learn by making different connections appropriate to individual experience. If our environment is restrained will we know our natural state, learning without fear and apprehension? The question of revolution and evolution becomes important when considering intentions, directions, and the goals of mathematical education in the larger context of education. Is it in wanting for our own mathematically invested selves that takes away from the open learning environment for our students? Do we modify zoo conditions, and then call it wild? Are balanced concessions to be made, or do we choose not to serve two masters? The conflict of how one naturally learns, and then how to teach teachers to teach students to learn is a debated and crucial question. How is teaching different from learning? We do both naturally, learning and passing on information, yet often when in position of authority we limit, if not deny open opportunity to others. But what does teaching/learning look like in formal agreement without inhibiting students or giving in to the bias of corrupted teaching practices? How do we fix the game? Change the rules or change the game? I left with questions on my mind about how what I do supports which game and to what end, personally, for the students I have, as well as for evolutionary long range mathematical understanding as it contributes to expanding the qualities and the evolving life we share.

Other thoughts while driving back to Chicago…

In regards to the issues about learning and teaching; it seems there are necessary conditions that naturally urge and require we learn, which is not usually part of the conversation about teaching. Anything we learn must be to some end, practical, progressive, having meaning for the individual, and must be personally experiential. These are of little consideration in training professional teachers, especially with primary

level. These aspects are crucial and need to be fully addressed if we want students interested and excited about learning mathematics. Math is a practical way of thinking; it is a tool, not a worldview. It must progressively build upon itself as a process of continuously revealing information, where the meaning is always in the larger context of other tools and information. Without the individual level of personal experience learning does not happen. To learn is to actively understand. Giving away what we learn makes understanding our own, which then brings sense making of knowledge into teaching. On the most hoped-for level this approaches wisdom, appropriately applied knowledge for the greater benefit of both teacher and student.

There is an assumption that wisdom is an expanded knowledge base that comes with exposure and age; thus top down thinking. Wisdom is never evidenced unless through knowledgeable interaction directly in the "wilds" providing experience appropriate to desired results of higher order functioning. How does mathematical knowledge do this? What is the intuitive, or creative component that is beyond human knowledge? Mathematics is one way to understand general functions about the physical of where we are, how it works, why we are here, how we got here, and to find reliable constants to make predictions about future outcomes. This last objective seems counter to the observations of life as an ever changing, often spontaneous, creative expression of something ordered, principled, whole, and without interruption; and yes, unexplainable.

The mind is the fulcrum between knowledge of the physical and the spiritual nature of man. We are a three-component, structural, regenerative system. We educate the mind to mostly 1/3 of what we are. Information is past between generations with some general continuity. What is left out will not be known to future generations. We pass on knowledge without knowing what will be required of students to reform and improve human conditions. Students need to know what the teacher does not know. Generational bias becomes our educational handicap; it creates a zoo, similar to a species bias in "The Planet of the Apes". We like the idea that everything can be discretely described and put into a formula that will yield predictable results. This seems to be a practical and logical use of mathematics. Every failure and dead end direction was once a logical and practical solution. How does our understanding of what is practical fit to planetary conditions today? Are the tools of technology a practical use of mathematics, or are we missing something that is more fundamental, more practical to our long-range survival?

As a possible analogy, let's use a biological cell as a community of individualized functions and how it might work to model a mathematical cell in a complex educational system. The knowledge center or cell direction used to be thought to come from the nucleus which now seems to be more a storage unit appearing to have no direct interaction with the outside "wilds", the context beyond the cell wall. The cell wall separates the identity from the environment, yet is also the place where interaction occurs to maintain intelligent cell function. The boundary identifies and takes in nourishment, it eliminates waste when necessary. Outside the wall is the context that provides purpose, health, and physical survival to cellular existence. Activity through the cell wall happens in two directions, keeping out what is not necessary and taking in nutrients for continued

growth and development. What is no longer useful within the cell is eliminated through the wall. If these functions stop the cell dies. Possibly this reveals a simplicity of workability that has some relevance to the reorganization of math education in regards to the knowledge about and sense making activities. Any meaningful action towards workability will require a collective willingness to make principled decisions towards sensible and substantial change along boundary walls. This is not a question about tools, rather how we use them, and the willingness to organize to do what is practical for the benefit of both cell and environment. This is the same conflict we face between a knowledge driven destruction of the human environment, and a sense of the wilds as a principled, healthy, and naturally ordered planet.

b) Reflections from Bron Ewing

The key theme of the group centred around Maths in the Wild and Maths in the Zoo (Flewelling, 2007). Discussions of this theme focused on the knowledge game and the sense meaning game and were expanded upon via the presentations of conference participants. From my reflections, conversations with others and my research on traditional and reform mathematics the following emphasises my views, although somewhat theoretical, on the rich task working group, in particular, the idea of a community of inquiry as significant for the sense making game and the comprehension of a discourse as the process of meaning.

In mathematics education, a community of inquiry views mathematics as an evolving human construction . Through inquiry, teachers are viewed "less as the infallible experts" (p. 82) and more as people who talk and think about mathematics through interaction with their students. This aspect, although not always evident in the working group, was identified in the presentations in the working group. The role of the teacher is significant to transforming a classroom to a community . That is, the teacher encourages and engages in discussions with students, scaffolding their interactions and participation in the inquiry. In doing so, the students are expected to listen to one another, build on ideas, challenge these ideas, provide reasons for unsupported opinions, and identify one another's assumptions. For several of the presentations this was particularly the case. Indeed there were many rich conversations about mathematics – challenges, solutions and explicit sense making. The elegance of what was mathematical was a highlight and was embraced by many participants. In a sense, their knowledge of the discourse meant they had the power to be actively involved.

To have knowledge of a discourse is to have power. Comprehending a discourse involves the processing of meaning . Meaning is the effect of the interaction between a speaker and a listener . It arises through the interaction between different speakers – here conference participants. To understand the meaning of what the speaker has said, the listener has to orient themselves with respect to it and its corresponding context . It cannot be understood and explained outside a social context . It is realised in and through the process of active and responsive understanding - it is the effect of the interaction between participants produced via the theme of the content (Volosinov, 1973). This effect precludes the claim that the knowledge game, or put another way, traditional mathematics, is that learning mathematics is simply about transmitting knowledge to the individual. Rather, in Bakhtin's (1984) view of "ventriloquation," (Wertsch, 2001, p.

234) the voice one uses is never responsible for creating meaning, instead it commences with words grounded in someone else's meaning. Thus, to produce and understand discourse, requires the processing of meaning during interactions in social contexts. It also requires a knowledge component.

c) Some Reflections from Gideon Weinstein

A Rich Learning Task includes the objects of reflection (real, virtual, or imagined) as well as a set of rules and expectations about how to interact with these objects. In Charlotte, the presenters exposed us to many rich learning objects (for example, fraction cubes, knots with and without soap films, folding paper, textbooks, problem sets, and so on) and we saw many different sets of expectations about what to do with these objects. Granted that some presenters might have decided to play the Knowledge Game with us because of the short duration of our sessions, it was clear that other presenters, no matter how rich their learning objects, clearly weren't aware that the Sense-Making Game existed and would have been a far better way to interact with those objects. This lack of awareness by some presenters at the conference is replicated in the larger world of school and college teachers. This points out an important dilemma: how does a teacher who is a Knowledge Game player become a Sense-Making Game player? Sometimes, the urge to change comes from within, tapping into childhood or college learning experiences that model a different way to play the game, sometimes motivated by frustration at the lack of true teaching success that often accompanies the Knowledge Game. Other times, the urge to change will need to come from without, in pre-service and in-service professional development activities. In this case, the professional development provider is faced with the crucial question of whether to focus these activities on fostering a slow step-wise evolution from one type of game-playing to another, or on a creating the knowledge and desire for a revolutionary change. I think the answer to that question is "It depends." With a (self-)satisfied crowd who will be hard to budge because they perceive themselves as successful teachers, the evolutionary nudge will be the right focus (but plant some revolutionary seeds for the silent/silenced dissenters). With a dissatisfied crowd, the revolutionary cause will be embraced more readily because the usual game isn't working (but provide some evolutionary steps for those who are uncertain or reluctant).

d) Some Reflections from Glenn Sproul

I came to the Charlotte conference without a clear idea of what to expect, but settled into Working Group Six (Rich Learning Tasks) because it seemed to offer the best hope for making progress toward two personal goals:

(1) Deepening my understanding of how to be most effective in my own mathematics classroom, and with my students generally;

(2) Enhancing my awareness of ways to bolster the Quantitative Reasoning (QR) skills of students in my college of about 1500 students.

I think Group Six was in fact a good choice for me. The depth and sensitively nuanced nature of our discussions and the probing questions raised were invigorating, inspiring and enlightening to me, even though most of our questions led to more questions rather than to clear answers and closure. And overall I feel reassured and affirmed in my thoughts about teaching mathematics, rather than discouraged by the recognition of my frequent failure to live up to the ideals we discussed.

Here are some of the nuggets I will carry away from our discussions to help guide my continuing development as a mathematics teacher:

(1) I can try to be aware at all times of the kind of game (e.g. the knowledge game, the sense-making game, or some blend of the two) I am engaging my students in.
(2) We can learn from "math-in-a-zoo" (the knowledge game, artificial and simplified as it may be) for a while, if it is appropriate, and then I can explicitly invite my students to go "into the wild" with me, "on safari" as it were, to explore a richer context with less predictable (and more interesting) results.
(3) Providing opportunities for learning math "in-the-wild" (i.e. rich learning tasks) probably requires that I:
    - give contexts/materials/sample problems initially in a way that allows and encourages students to explore freely, without particular ends imposed by me;
    - give students a major role in creating the materials and contexts to be explored, whenever possible;
    - urge students to observe and describe what they see and discover in any learning activity;
    - help students develop their observational and descriptive skills by having them repeat, rephrase and build on the observations of their peers;
    - encourage students to use their own language for observing and describing, until and unless the need for special terms becomes apparent to them during the activity.
(4) Enriching learning activities by these and other means can make my (college) classroom become more fully a community of learners, just as, perhaps, we in Group Six have been a community of learners for a few days. Thank you Gary, Jack, Hank, Brad, Gideon, Fernando, Linda and Bronwyn, and the others who joined us from time to time. It was a valuable and memorable time for me, and I hope some of us will resume our conversation in the future.

e) Some Reflections from Linda Sheffield

Rich Learning Tasks and the Brain

Research on the functioning of the brain can inform much of our work with rich learning tasks. In many cases in school, students are asked to memorize information without understanding why or how that information has been constructed. This emphasis may put information into a child's short-term memory, but the transfer of meaningless information from short-term to long-term memory is a difficult one as shown by the difficulty many students have in using an aid such as flash cards to memorize their multiplication tables.

Long-term memory and short-term memory differ in capacity, brain structure

and location just as they differ in the length of time that they function. Short-term memory is limited, lasts for under 30 seconds, and requires repeated, spaced repetition to have the potential to move to long-term memory. Long-term memory seems to be unlimited, may be immediate, and may last anywhere from 30 seconds to a lifetime. Meaning, purpose, and connecting new information to existing concepts already in memory can enhance long-term memory. An active search for understanding, patterns, visual or concrete images, and enjoyable experiences all add to a student's ability to remember and make sense of large amounts of information. Rich learning tasks have the potential to stimulate this long-term memory, connections to earlier understanding, and the enjoyment of solving challenging problems.

I think that this relates well to the sense-making and the knowledge games. I think that sense-making fits very well with what is known about how the brain functions. It would be great to explore this further.

f) Reflections by Gary Flewelling

1. The 'Rich Learning Tasks' / 'Sense-Making Game' / 'Math in the Wild' Working Group should reconvene in Dresden.

2. More attention should be given to recent findings in brain research and their implications for our working group.

3. Additional attention should be given to how to motivate (and equip) teachers to adopt and play the sense-making game in their classrooms.