Key Elements of Successful QS Learning Opportunities in Geoscience:

The following set of principles is based largely on the summaries of the research on learning which are referenced below.

1. ACTIVE INVOLVEMENT

The more students are actively engaged with their own learning, the more they learn. Students learn better when they are presented with intrinsically motivating problems and are provided the support and encouragement to discover relevant knowledge about those problems. Well designed group activities require students to develop problem solving strategies, articulate their mathematical ideas in words and in writing and to argue with peers about which strategies to employ.

2. METACOGNITION I: LEARNER INDEPENDENCE AND CHOICE

Metacognition is the act of consciously monitoring one's own learning in order to become aware of how one best acquires knowledge. Individual learning strategies are then developed based on these insights. The research on learning shows that this act of self-reflection is itself a powerful learning tool even when it is not apparent that effective strategies are developed.

3. METACOGNITION II: CONFRONTING MISCONCEPTIONS

New ideas and knowledge are largely constructed out of existing ideas (roughly 80% in most cases). If the existing ideas contain misconceptions, chances are the new knowledge too will be flawed. For this reason students should be urged to consciously identify and confront their own misconceptions. Learning activities should be designed to help identify and correct these misconceptions. For example, students could be asked to make predictions and to compare these to the actual results. By consciously addressing the difference between prediction and reality the learner would have the opportunity to make necessary adjustments to their accumulated understanding.

4. SOCIAL INTERACTION:

Social interaction is a powerful and innate capacity of humans. Our brains are have evolved to master complex ideas and relationships while interacting with others. Student

learning is enhanced by tapping into this innate capacity through activities that require students to interact as part of their learning experience.

5. HIGH-CHALLENGE, LOW-THREAT ENVIRONMENTS

The brain has multiple functions. The same organ processes sensory data, produces emotions, and provides cognitive functioning. Emotional well-being is essential to intellectual functioning. Marchese writes: "When humans confront a situation they perceive as threatening, their brain "downshifts" . . . higher-order cortical functioning is supplanted by the more elemental limbic . . . the emotions come to rule." Learning is enhanced by challenge but inhibited by threat.

6. TIMELY, USABLE FEEDBACK WITH OCCASIONS FOR REFLECTION

Student learning is improved when students are required to express ideas and get timely feedback on them. Students must have time to reflect on the critiques they receive, make adjustments, and try again.

7. APPROPRIATE USE OF TECHNOLOGY

Calculators and computers should be used to help students visualize and explore data and relationships, not just to follow algorithms to predetermined ends. Computer-based instruction appears to help students learn by providing a tool to explore different ways to represent the same information.

8. PRACTICE AND REINFORCEMENT

Garfield writes: "Students … learn better if they have experience applying ideas in new situations. If they practice only calculating answers to familiar, well-defined problems, then that is all they are likely to learn. Students cannot learn to think critically, analyze information, communicate ideas, make arguments, tackle novel situations, unless they are permitted and encouraged to do those things over and over in many contexts. Merely repeating and reviewing tasks is unlikely to lead to improved skills or deeper understanding."

REFERENCES

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