

Advancing learning content in the sciences: A vision for developing rich scientific literacy

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Many science courses, especially at the introductory level, focus on covering the content and helping students build a disciplinary knowledge base and not on developing scientific literacy. Instead, we will discuss and use a model for teaching scientific literacy based upon a system for teaching content. This system considers different strategies, such as using concept maps and organizing schemes for teaching content so that students develop scientific habits of the mind. Participants will consider how they can use content to promote critical inquiry and foster the application of content in the future. Participants will begin to plan re-envisioned courses that involve active student engagement and hands-on activities to help students use scientific concepts to address real challenges. This session, consistent with the conference vision theme, applies to all types of institutions of higher education and all levels of participants, but will especially focus on general education or introductory courses.

Scientific literacy is the ability to read scientific literature, use scientific knowledge to solve problems, learn more, and think critically.

Answer the questions that pertain to your teaching.

What evidence do you have that your entry level students are or are not becoming scientifically literate?

What evidence do you have that your advanced level students are or are not scientifically literate?

What barriers are preventing your students from becoming scientifically literate?

Much of this session comes from Blumberg, P. (2009) *Developing Learner-Centered Teaching: A Practical Guide for Faculty*. Jossey-Bass. You may use this material provided you cite the reference.

The Functions of Content to Promote Scientific Literacy with approaches/ tools associated with each component

Component	Approach/tools to encourage scientific literacy	How can you use these active student engagement, hands-on activities, learning to learn approaches/ tools in your own teaching to help students: <ul style="list-style-type: none"> • use scientific concepts to address real world challenges? • solve practical problems? • promote critical inquiry? • foster the application of content to future learning and use? • learn additional content that is not taught?
<p>I. Varied uses of content In addition to building a knowledge base, instructor uses content to help students:</p> <ul style="list-style-type: none"> ▪ evaluate and know why they need to learn content. Present specific content which is necessary to build a foundation for advanced studies ▪ acquire discipline-specific learning methodologies such as how to read primary source material 	<ul style="list-style-type: none"> ▪ Example: the relationship between cell structures and disease ▪ Example: the importance of membrane transport in relationship to muscle and neurological functions ▪ Example: administer learning style survey (VARK, www.vark-learn.com) to help students identify and utilize the strategies best suited for their learning and understanding of content. ▪ Example: introduce strategies to help students utilize educational resources, such as, charts, diagrams and CD accompanying the text. 	

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<p>I. Varied uses of content (continued) In addition to building a knowledge base, instructor uses content to help students:</p> <ul style="list-style-type: none"> ▪ practice using inquiry or ways of thinking in the discipline ▪ learn to solve real world problems 	<ul style="list-style-type: none"> ▪ Example: develop laboratory activities that promote questioning providing students with the opportunity to solve problems, not verifying content learned ▪ Example: provide scenarios that challenge students to think about solutions to a problem <ul style="list-style-type: none"> ▪ for more detail see the accompanying sheet ▪ Example: provide scenarios, crime scene investigations or physiology events that challenge students to think about alternative solutions 	

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<p>II. Students actively engage in content Instructor encourages students to transform and reflect on <u>most</u> of the content to make their own meaning out of it</p>	<ul style="list-style-type: none"> ▪ Interactive notebook <ul style="list-style-type: none"> - Example: Students write lecture notes on the left page of their notebook and on the right side students utilize a variety of methods to clarify their notes based on their reading of the text. - for more detail see the accompanying sheet ▪ Concept Maps <ul style="list-style-type: none"> - Example: Students develop a visual representation of content knowledge, showing the interrelationships of information - for more detail see the accompanying sheet 	

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<p>III. Use of organizing schemes Instructor provides and uses organizing schemes to help students learn content that is not taught</p>	<p>All disciplines have themes that unite most of the content. Making these themes explicit to the students help them to see the big picture</p> <ul style="list-style-type: none"> ▪ Themes in Biology <ul style="list-style-type: none"> - structure/function relationships - cellular basis of life ▪ Example: Weave major themes throughout the course. It is essential to identify the themes early in the course so that students begin to develop a deeper understanding of the major concepts and principles. Students build connections between isolated facts and the big picture. 	

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<p>IV. Use of content to facilitate future learning Instructor frames and organizes content so students can learn additional content that is not taught</p>	<ul style="list-style-type: none"> • Metacognition Example: Instructor models how to solve problems and answer 	

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Functions of Content to Promote Scientific Literacy

1. Varied Uses of Content

- **Evaluate why they need to learn content**
 - Present specific content which is necessary to build a foundation for advanced studies.
 - Example: the relationship between cell structures and disease
 - Example: the importance of membrane transport in relationship to muscle and neurological functions
- **Acquire discipline-specific learning methodologies**
 - Example: administer learning style survey (VARK) to help students identify and utilize the strategies best suited for their learning and understanding of content.
 - Example: introduce strategies to help students utilize educational resources, such as, charts, diagrams and CD accompanying the text.
- **Practice using inquiry or ways of thinking in the discipline**
 - Example: develop laboratory activities that promote questioning providing students with the opportunity to solve problems, not verifying content learned.
 - Example: provide scenarios that challenge students to think about solutions to a problem.
 - A lab assistant was preparing test tubes filled with plant cells or animal cells. He was distracted and didn't get a chance to label the test tubes. How is he going to find out which tubes contain animal cells and which contain plant cells.
- **Learn to solve real world problems**
 - Example: provide scenarios, crime scene investigations or physiology events that challenge students to think about alternative solutions.

II. Level at which students engage in content

Instructor encourages students to transform and reflect on most of the content to make their own meaning out of it.

- **Interactive notebook**
 - Example: Students write lecture notes on the left page of their notebook and on the right side students utilize a variety of methods to clarify their notes based on their reading of the text.

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Lecture Notes	Textbook Notes
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- Students review their notes and identify material that is confusing, unclear and/or incomplete by placing a question mark next to materials that needs clarification.
- Students read small sections of the text that corresponds to the material in the lecture notes. (chunking material)
- On the right side of the notebook, students enhance their understanding of the material by:
 - Adding drawings
 - Paraphrasing the text material
 - Making tables
 - Drawing charts or maps
- **Concept Maps**
 - Example: Students develop a visual representation of content knowledge, showing the interrelationships of information. Using post-it notes, students are given the opportunity to brainstorm, listing as much information about a topic as they can. Once the brainstorming is over, students begin to group terms. Within each grouping, students develop a hierarchy. During the two previous steps, students are discussing the rationale for the groupings and hierarchy. Once the discussions are finished, the students construct a map.
 - Example: A variation on this activity is to use the concept mapping as a pre-assessment technique. During the study of a topic, students will add to their original map. The completed map shows the growth in students' understanding of a topic.

III. Use of organizing schemes

Instructor provides and uses organizing schemes to help students learn content.

- Themes in Biology
 - Example: Each course has major themes that are woven throughout the course. It is essential to identify the themes early in the course so that students begin to develop a deeper understanding of the major concepts and principles. Students build connections between isolated facts and the

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big picture. Some of the themes used in a general biology course are structure/function relationships and cellular basis of life.

IV. Use of content to facilitate future learning

Instructor frames and organizes content so students can learn additional content that is not taught

- Metacognition
 - Example: Instructor models how to solve problems and answer questions.

Planning For Transformation Exercise

Choose a few tools/ approaches/ examples from among the ideas and methods we have discussed that you think you could use. We will get together in groups working on similar tools to plan ways to transform your current practice to achieve scientific literacy.

A. **Status of your course now** Date:

Briefly describe what you do now (for the purposes of documenting your baseline prior to transformation).

B. **Desired changes**

Describe the desired change(s) you wish to implement in the near future.

C. **Tactical planning questions**

1. What do you need to do, decide or learn about prior to making changes?
2. What obstacles or challenges do you need to overcome to implement successfully this change? (Resistance may come from your philosophy of teaching, your chair, your peers, your students, or the culture of your institution.)
3. Identify specific strategies (such as learning about successful implementations, trying a small pilot implementation, explaining to your students and other instructors why you are making these changes) for overcoming each obstacle or challenge.
4. What resources (such as time, money, student assistants, or computer software) would help you implement your change?

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5. What do you need to do to get your students to accept this change? (Possibilities include repeated explanations for why you are doing what you are doing or having the activity count in the final grade.)

D. Outcomes of the change

1. In what ways (such as increased learning), will your students benefit from this change especially as it relates to scientific literacy? How will the students behave differently (such as increased participation in class or greater engagement with the content)?

2. In what ways will you benefit from this change? (For example, - enjoy teaching more, satisfied that your students are learning more, anticipate fewer student complaints)

E. Possible future changes

In the long term, what additional changes, if any, might you make to transform further this component to reach an optimal level of scientific literacy among your students?