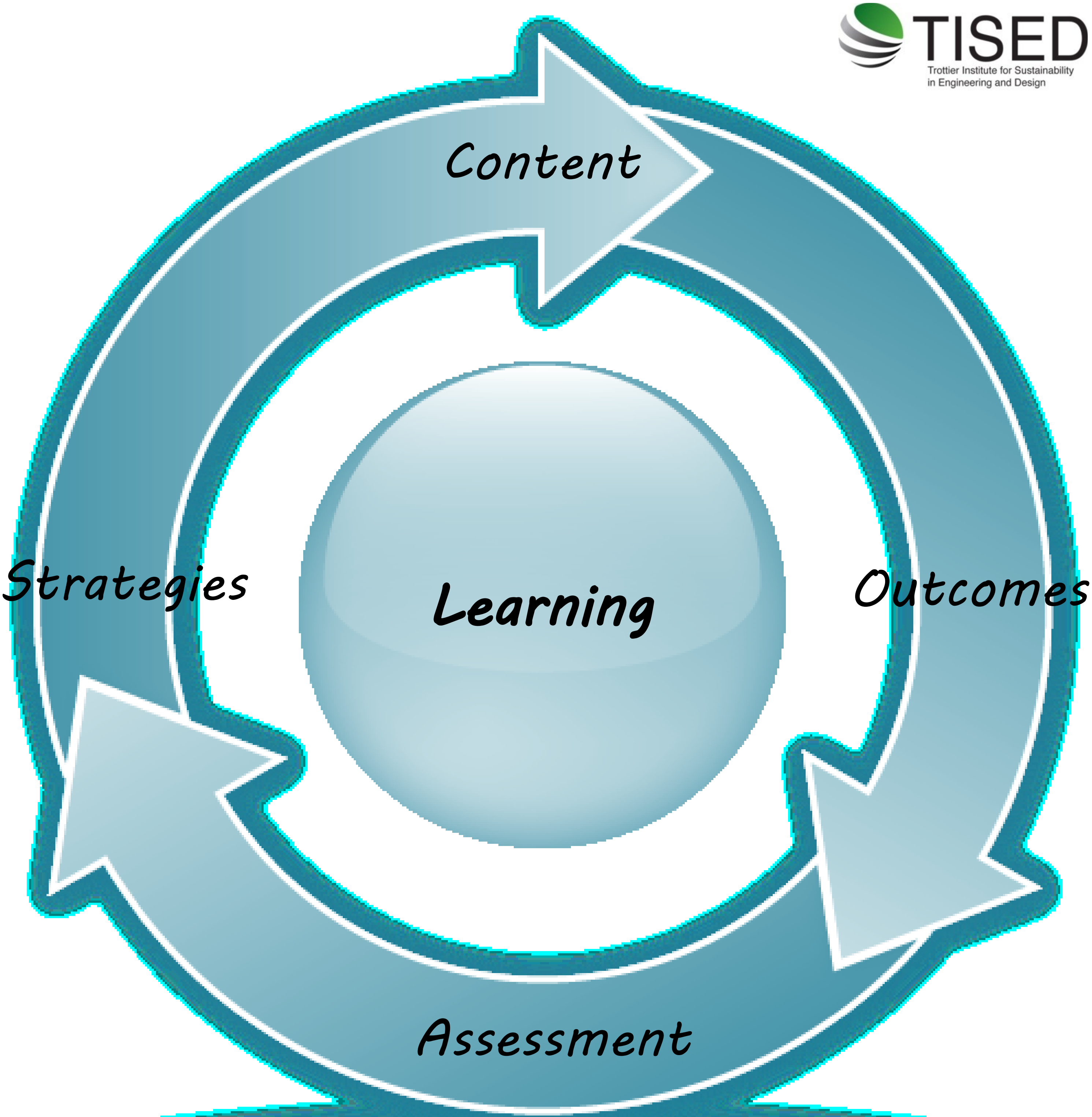

Integrating sustainability into your courses: a curriculum workshop for Engineering, Architecture and Urban Planning

TISED
Trottier Institute for Sustainability in Engineering and Design

May 14-15, 2014

Teaching and Learning Services (TLS)

McGill

Table of Content

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<u>Workshop Description</u>

Goals

During this workshop participants will:

1. Learn how to add sustainability-related content to your courses
2. Apply learning-centered course design principles and strategies to the (re)design of one of your courses;
3. Exchange feedback with peers to improve course design and teaching approaches
4. Benefit from the experience of faculty colleagues and students who share their learnings on sustainable/sustainability-related engineering curriculum

Strategies

The workshop has four components:

1. <u>Pre-workshop preparation</u>
   Upon registration, participants will be asked to complete a short questionnaire. Before the workshop a list of suggested readings will be uploaded to *mycourses.*
2. <u>First-day workshop</u>
   The workshop includes interactive activities, mini lectures on course design and sustainability in Engineering, and exercises where participants apply course design principles to a specific course in their discipline.
   Please see *Agenda: Day One* on the next page.
3. <u>Second-day workshop</u>
   Undergraduate students and grad Participants present their course outlines and exchange feedback.
   Please see *Agenda: Day Two* on the next page.
4. <u>Follow-up activity</u> (to be scheduled during the fall term 2014)
   This is an opportunity for participants to reconnect with each other and discuss how they have applied ideas from the workshop to their own teaching.

Agenda

Integrating sustainability into your courses: a curriculum workshop for Engineering, Architecture and Urban Planning – May 14th and 15th, 2014

Location: McIntyre Medical Bldg, 2nd floor

14-May	
Time	**Topic/Activity**
8:30-9:00am	*Coffee/Tea*
9:00-9:05am	Welcome
9:05-9:20am	Introductions
9:20-9:35am	Systems Thinking
9:35-10:40am	Concept map of sustainability
10:40-11:10am	Fundamental principles of sustainable engineering and sustainability metrics
11:10am-12:00pm	Presentations on experiences integrating sustainability content and concepts in courses and Q&A
12:00-1:00pm	*Lunch*
1:00-1:45pm	Review and identify course outline
1:45-2:30pm	Learning Outcomes: introduction and hands-on exercise
2:30-3:30pm	Active Learning & Engineering-specific strategies
3:30-4:30pm	Feedback and Assessment: introduction and hands-on exercise
4:30-4:35pm	Preview of tomorrow

5:30-7:00pm	*Everyone is invited to a public event: "Engineering Education: A Paradigm Shift into High Gear" - Dr. Cliff Davidson – details on page 2*	*Faculty Club*

15-MAY	
Time	**Topic/Activity**
8:30-9:00am	*Coffee/Tea*
9:00-9:05am	Welcome: Review of yesterday's activities
9:05-10:00am	Student perspectives and Q&A discussion
10:00am-12:00pm	Individual hands-on work on course: one-on-one interactions with workshop leaders
12:00-1:00pm	*Lunch*
1:00-3:00	Presentations on course syllabi and content session: small group discussions, peer critiques and discussion
3:00-3:30pm	Q&A with panelist presenters and feedback
3:30-3:45pm	*Break*
3:45-4:30pm	Workshop Evaluation

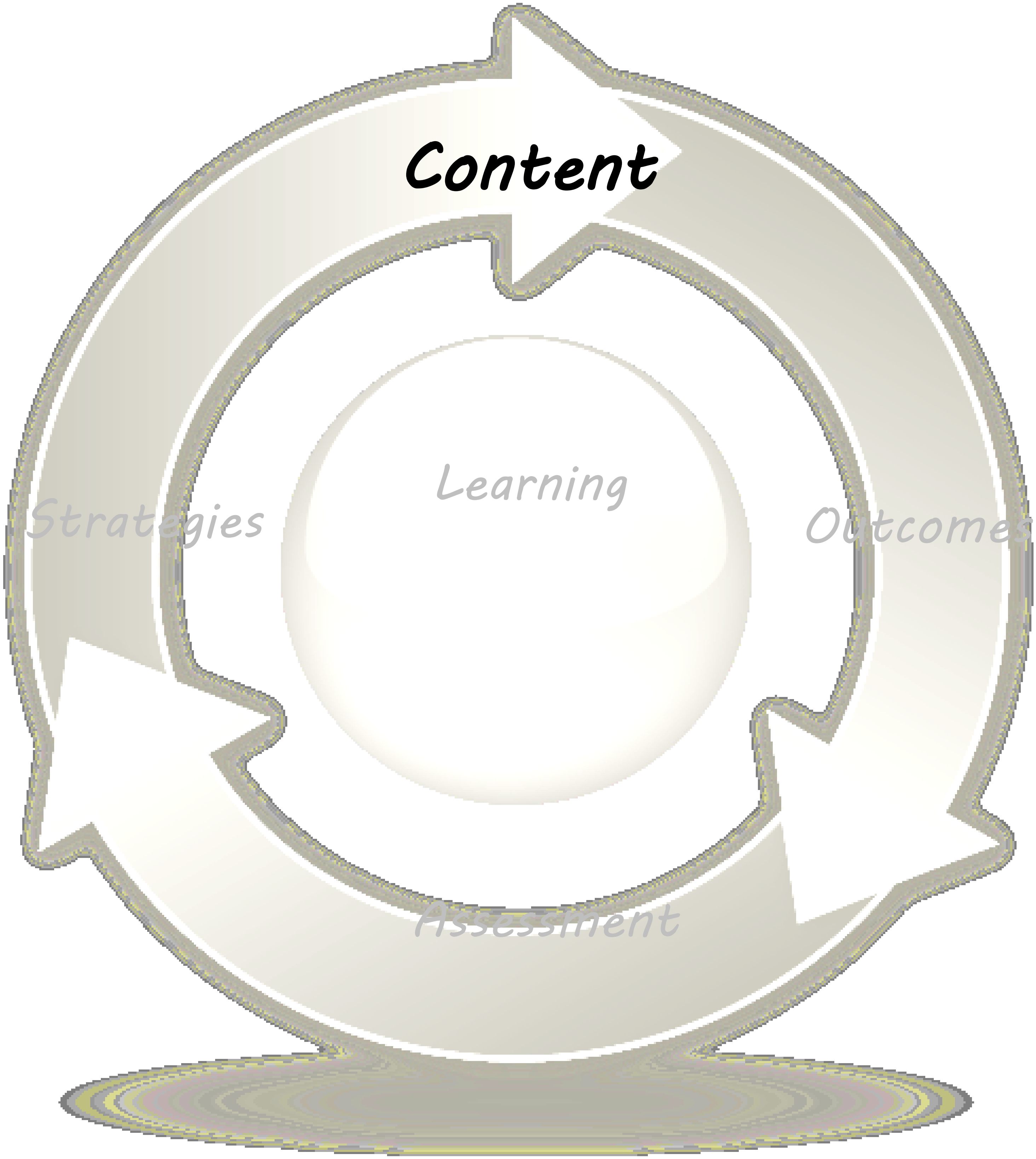
Public seminar on May 14th

"Engineering Education: A Paradigm Shift into High Gear", a talk by Dr. Cliff Davidson

Wednesday, May 14th, 5:30-6:30pm, McGill University Faculty Club, 3450 Rue McTavish

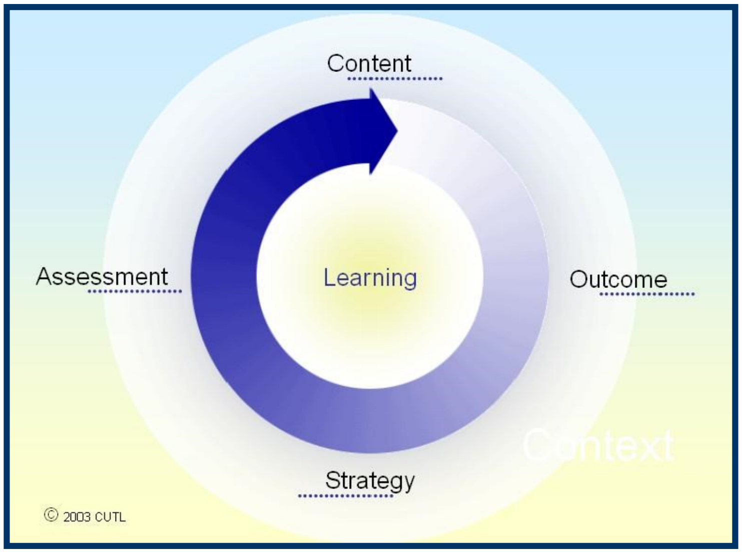
Dr. Davidson, will present the 'why' and 'how' of engineers' re-education on new local and global environmental concerns. Engineering, architecture, and urban planning work around the world is changing rapidly - instructors and students need to keep up with the changes and see how their work can be applied to make our society more sustainable. This is a free event, open to the public, no registration required and light refreshments will be served.

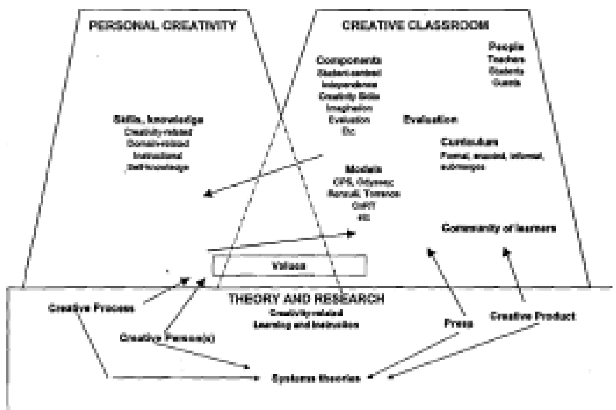
About this speaker: Dr. Cliff Davidson is the Director of the Center for Sustainable Engineering, a partnership among Syracuse University, Arizona State University, and the Georgia Institute of Technology. Since the 1990s, Dr. Davidson has studied the role of engineers in sustainable development as well as public perception of technology and public understanding of the environmental impact of daily activities. He is currently researching urban redevelopment for sustainability, considering the role of green infrastructure in helping to solve air and water management issues.

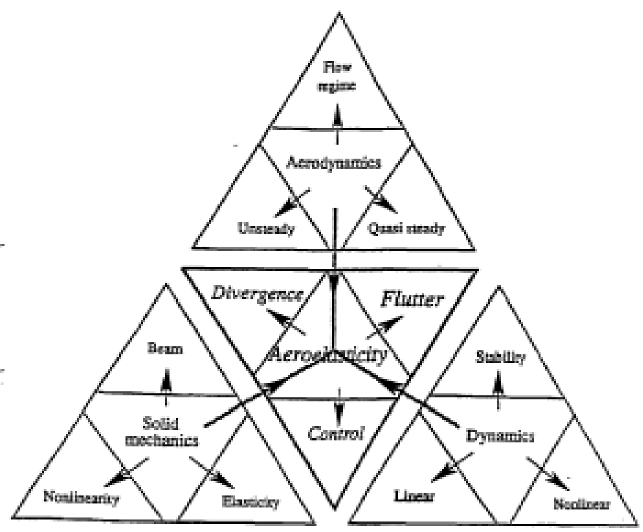

Content
Learning
Strategies
Outcomes
Assessment

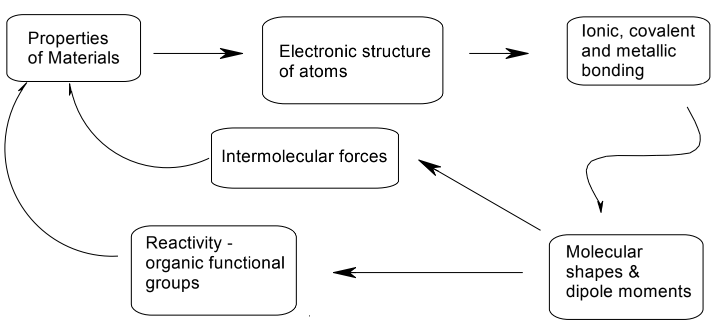
Examples of Concept Maps

Concept maps are visual displays that illustrate the relationships between concepts/ideas in a content area (Jonnassen, Beissner &Yacci, 1993)









References / Resources

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Hay, D., Kinchin, I., & Lygo-Baker, S. (2008). Making learning visible: The role of concept mapping in higher education. *Studies in Higher Education*, *33*(3), 295-311.

Jonassen, D.H., Beissner, K., and Yacci, M. Explicit Methods for Convening Structural Knowledge Through Concept Maps. In: *Structural Knowledge: Techniques for Representing, Conveying, and Acquiring Structural Knowledge*. Hillsdale, NJ: Erlbaund, 1993. pp.155-163.

Whetten, D. (2007). Principles of effective course design: What I wish I had known about learning-centered teaching 30 years ago. *Journal of Management Education, 31*(3): 339 - 357.

A periodic table of visualization methods: http://www.visual-literacy.org/periodic_table/periodic_table.html

Exercise 1: Creating a Concept Map

Step 1 (20 minutes)

- Quick writing: What do you think of when we say sustainability? Please write everything that comes to mind. Focus on sustainability as a concept, not on how you would teach it.
- Review your response to the question above. Take a few minutes to write any additional information.
- Circle the main concepts or ideas related to your definition of sustainability. If you notice any that are missing, please add them.
- Write each concept on a post-it note and transfer these to the green folder provided.
- Arrange these post-it notes in a meaningful way:
  - Are some related to others? Is there a sequence? Are some pre-requisites to others?
  - Can you think about a visual representation that would capture the relationship between these concepts or ideas?

Step 2 (15 minutes)

- Pair with another participant and exchange feedback about your concept maps (see “suggested ways to critique a concept map” below).

Step 3 (10 minutes)

- Revise your concept map integrating the feedback received.

Suggested Ways to Critique a Concept Map

1. Are any concepts stated verbally that are not included in the map?
2. What is the specific relationship between or among each of the concepts?
3. Is it easily apparent which concepts are central or important?
4. Is it easily apparent which concepts are peripheral or less important?
5. Have any relationships been overlooked?
6. What would happen if “x” concept was moved?

Reminder: Creating a concept map is an ongoing process and your map will likely undergo changes. You can save successive drafts to track the development of your map.

Sustainability in Engineering 12 Principles of Green Engineering

Through the 12 Principles GREEN Engineering

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Sustainability requires objectives at the molecular, product, process, and system levels.

MICK WIGGINS

In recent years, numerous papers, books, and conferences have centered on the subject of lessening the negative human impacts on the planet and on its ability to sustain life (1–7).

Often, from these discussions, specific goals have emerged, such as minimizing waste, increasing recycling, or approaching sustainability (8–10). Goal statements can be very useful in providing a vision of what needs to be achieved, and many of these discussions contribute to important parts of that vision. Yet, goals are only effective when they become reality. Approaches are being developed to achieve these goals across disciplines, industries, and sectors. It is clear, however, that these approaches are currently neither systematic nor comprehensive.

Green engineering (11) focuses on how to achieve sustainability through science and technology (12–14). The 12 Principles of Green Engineering (see box on the next page) provide a framework for scientists and engineers to engage in when designing new materials, products, processes, and systems that are benign to human health and the environment. A design based on the 12 principles moves beyond baseline engineering quality and safety specifications to consider environmental, economic, and social factors.

The breadth of the principles' applicability is important. When dealing with design architecture—whether it is the molecular architecture required to construct chemical compounds, product architecture to create an automobile, or urban architecture to build a city—the same green engineering principles must be applicable, effective, and appropriate. Otherwise, these would not be principles but simply a list of useful techniques that have been successfully demonstrated under specific conditions. In this article, we illustrate how these principles can be applied across a range of scales.

It is also useful to view the 12 principles as parameters in a complex and integrated system. Just as every parameter in a system cannot be optimized at any one time, especially when they are interdependent, the same is true of these principles. There are cases of synergy in which the successful application of one principle advances one or more of the others. In other cases, a balancing of principles will be required to optimize the overall system solution. There are, however, two fundamental concepts that designers should strive to integrate at every opportunity: life cycle considerations and the first principle of green engineering, inherency.

The 12 Principles of Green Engineering

Principle 1: Designers need to strive to ensure that all material and energy inputs and outputs are as inherently nonhazardous as possible.

Principle 2: It is better to prevent waste than to treat or clean up waste after it is formed.

Principle 3: Separation and purification operations should be designed to minimize energy consumption and materials use.

Principle 4: Products, processes, and systems should be designed to maximize mass, energy, space, and time efficiency.

Principle 5: Products, processes, and systems should be "output pulled" rather than "input pushed" through the use of energy and materials.

Principle 6: Embedded entropy and complexity must be viewed as an investment when making design choices on recycle, reuse, or beneficial disposition.

Principle 7: Targeted durability, not immortality, should be a design goal.

Principle 8: Design for unnecessary capacity or capability (e.g., "one size fits all") solutions should be considered a design flaw.

Principle 9: Material diversity in multicomponent products should be minimized to promote disassembly and value retention.

Principle 10: Design of products, processes, and systems must include integration and interconnectivity with available energy and materials flows.

Principle 11: Products, processes, and systems should be designed for performance in a commercial "afterlife".

Principle 12: Material and energy inputs should be renewable rather than depleting.

Life cycle and inherency

The materials and energy that enter each life cycle stage of every product and process have their own life cycle. If a product is environmentally benign but is made using hazardous or nonrenewable substances, the impacts have simply been shifted to another part of the overall life cycle. If, for example, a product or process is energy efficient or even energy generating (e.g., photovoltaics), but the manufacturing process consumes energy to a degree that offsets any energy gains, there is no net sustainability advantage. Accordingly, designers should consider the entire life cycle, including those of the materials and energy inputs.

The life cycles of materials and energy begin with acquisition (e.g., mining, drilling, harvesting) and move throughout manufacturing, distribution, use, and end of life. It is the consideration of all of the impacts that is needed when applying the green engineering principles. This strategy complements the selection of inherently benign inputs that will reduce the environmental impact across life-cycle stages.

Making products, processes, and systems more environmentally benign generally follows one of the two basic approaches: changing the inherent nature of the system or changing the circumstances/conditions of the system. Although inherency may, for example, reduce the intrinsic toxicity of a chemical; a conditional change can include controlling the release of, and exposure to, a toxic chemical.

Inherency is preferable for various reasons, most importantly to preclude "failure". By relying on technological control of system conditions, such as air scrubbers or effluent treatment, there is a potential for failure that can lead to a significant risk to human health and natural systems. However, with an inherently more benign design, regardless of changes in conditions or circumstances, the intrinsic nature of the system cannot fail.

In those cases in which the inherent nature of the system is predefined, it is often necessary to improve that system through changes in circumstances and conditions. Although technological and economic factors may often preclude the adoption of an alternative system design that is more inherently benign, incremental changes in circumstances can have a very significant effect on the overall system. One example is the choice between designing personal transportation in the most environmentally benign and sustainable way versus designing a gasoline-powered sport utility vehicle to be the most sustainable.

The 12 Principles of Green Engineering provide a structure to create and assess the elements of design relevant to maximizing sustainability. Engineers can use these principles as guidelines to help ensure that designs for products, processes, or systems have the fundamental components, conditions, and circumstances necessary to be more sustainable.

The principles

More details about the application of the 12 principles across the four design scales are found in Tables 1–11 in Supporting Information at http://pubs.acs.org/est.

Principle 1: Inherent rather than circumstantial. Although the negative consequences of inherently hazardous substances (whether toxicological, physical, or global) may be minimized, this is accomplished only through a significant investment of time, capital, material, and energy resources. Generally, this is not an economically or environmentally sustainable approach. Designers should evaluate the inherent nature of the selected material and energy inputs to ensure that they are as benign as possible as a first step toward a sustainable product, process, or system. Similarly, molecular designers are developing methods and technologies to create inherently benign material and energy sources (15–18).

For cases in which inherently hazardous inputs are selected, the hazard will either be removed in the process, usually during purification or cleanup steps, or incorporated into the final output. Hazards that are eliminated in-process from the final product by optimized operating conditions will require constant monitoring and containment and may also require eventual removal to a permanent off-site storage and disposal facility. Each step requires engineered safety precautions that could fail. What if these hazards are not removed but instead incorporated into the

An important point, often overlooked, is that the concept of waste is human.

final product? Strategies for incorporating hazards into a product or process as long as the hazard is continually recycled and reused do exist, but this approach requires resource expenditure for monitoring and control throughout the hazard's lifetime. Furthermore, these methodologies depend on the transport of these hazards to maintain "closed-loop" cycling, thereby increasing the risk of release through accidents, spills, and leaks. Ideally, inputs to the system will be inherently less hazardous, which significantly reduces the risks of failure and the resources expended on control, monitoring, and containment.

Principle 2: Prevention instead of treatment. Proposals for manufacturing processes or service systems that are "zero-waste" are often criticized as ignoring the laws of thermodynamics and enthalpic considerations. An important point, often overlooked, is that the concept of waste is human. In other words, there is nothing inherent about energy or a substance that makes it a waste. Rather it results from a lack of use that has yet to be imagined or implemented. As such, waste is assigned to material or energy that current processes or systems are unable to effectively exploit for beneficial use. Regardless of its nature, the generation and handling of waste consumes time, effort, and money. Furthermore, hazardous waste demands even greater additional investments for monitoring and control.

Although it may seem obvious that waste generation should be prevented or avoided wherever possible, there are plentiful examples where it is not inadvertently generated; rather, waste generation is thoughtlessly designed into the process. Technologies targeted toward waste-free design at any scale are based on the same fundamental concept: inputs are designed to be a part of the desired output. This concept has been described at the molecular scale as "atom economy" (18) and can be extended across design scales as the "material economy".

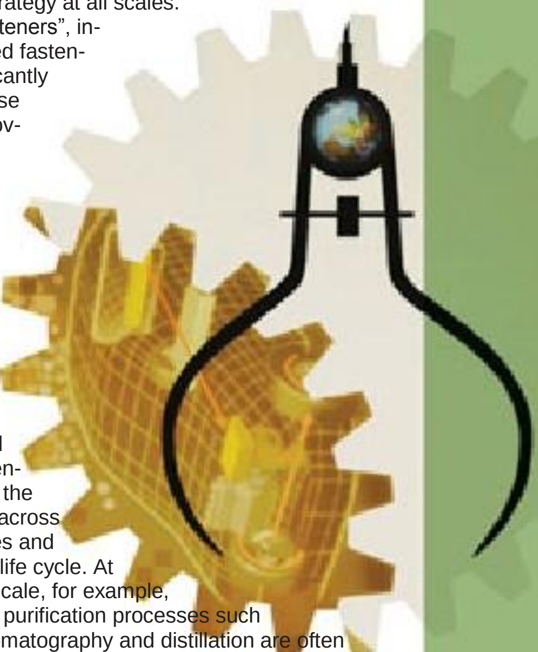
This principle can be illustrated by the design of current power generation systems based on fossil fuels, which inherently produce waste at each life cycle stage. Although waste is also generated during mining and processing, most is produced during use. Burning fossil fuels releases greenhouse gases and particulate matter, which contribute to global climate change and its subsequent impacts (19).

However, power generation systems do not have to produce waste, as exemplified by fusion energy. Although still unrealized, fusion energy could move energy systems toward sustainability (20). Fusion will eliminate the release of chemical combustion products because fossil fuels are not used. In addition, fusion energy does not form dangerous fission products that are associated with nuclear energy sources. Applying this strategy to energy systems illustrates that products, processes, and other systems can be designed to prevent the production of waste through elemental design considerations.

Principle 3: Design for separation. Product separation and purification consume the most energy and material in many manufacturing processes. Many traditional methods for separations require large amounts of hazardous solvents, whereas others consume large quantities of energy as heat or pressure. Appropriate up-front designs permit the self-separation of products using intrinsic physical/chemical properties, such as solubility and volatility rather than induced conditions, decrease waste and reduce processing times.

A similar design strategy can be applied across scales such that the final product, process, or system is shaped from components with desired properties. This approach minimizes the energy and materials necessary to isolate the desired output from a complicated matrix of undesirable and valueless extraneous matter. Furthermore, the components of the unwanted matrix are often classified as waste, which requires time, money, and resources for handling, transportation, disposal, and possible monitoring.

Additionally, design decisions at the earliest stage can impact the ease of product separation and purification for later reuse and recycling of components. Economic and technical limitations in separating materials and components are among the greatest obstacles to recovery, recycle, and reuse (21). These obstacles can be overcome by avoiding permanent bonds between two different materials wherever possible. Fasteners that are designed for disassembly should be incorporated into the basic design strategy at all scales. "Reversible fasteners", including threaded fasteners, can significantly improve the ease of material recovery, recycling, and reuse in cellular telephones to cars.

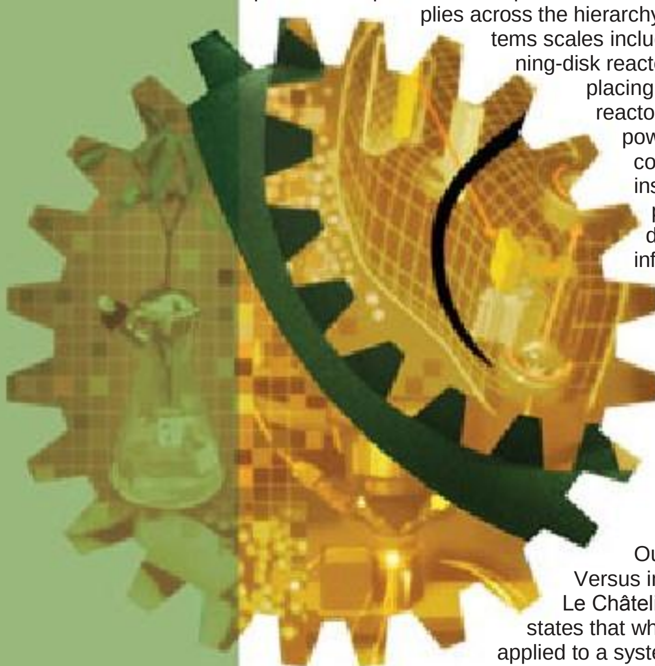


Up-front consideration for separation and purification avoidsthe need to expend materials and energy to harvest the desired output across all design scales and throughout the life cycle. At the molecular scale, for example, separation and purification processes such as column chromatography and distillation are often inefficient. Column chromatography can require large quantities of hazardous solvents (22), whereas distillation consumes significant amounts of energy, both in terms of cooling and heating requirements.

However, if chemical reaction products can be designed to self-separate from the reaction medium, it would eliminate the need for these additional resources. Polymers, for example, can be used to control the solubility of substrates, ligands, and catalysts for separation and reuse. Up-front consideration for separation and purification avoids the need to expend materials and energy to harvest the desired output across all design scales and throughout the life cycle (23).

Principle 4: Maximize mass, energy, space, and time efficiency. Because processes and systems often use more time, space, energy, and material than required, the results could be categorized as "inefficiencies", but the consequences are often broadly distributed throughout the product and process life cycles. If a system is designed, used, or applied at less than maximum efficiency, resources are being wasted throughout the life cycle. The same design tools traditionally used by engineers to increase efficiency can be even more broadly applied to increase intensity. That is, space and time issues can be considered along with the material and energy flow to eliminate waste. Furthermore, in optimized systems there is a need for real-time monitoring to ensure that the system continues to operate at the intended design conditions.

Historically, only a part of the available volume of large batch reactors in chemical manufacturing has been commonly used during the reaction period, often at dilution levels far more than required. Through process intensification techniques, such as Micro-reactors that operate continuously at very low volume with efficient mixing, high productivity can be obtained from small amounts of material (24). Similar strategies de signed for maximum efficiency and intensity can be applied across the molecular, product and process. Example of how this applies across the hierarchy of systems scales include spinning-disk reactors replacing batch reactors (24), powder coatings instead of paints, digital information rather than printed media, and eco-industrial plants to eliminate urban sprawl.



Principle 5: Output-pulled Versus input-pushed. Le Châtelier's principle states that when a stress is applied to a system at equilibrium, the system readjusts to relieve or offset the applied stress. A stress is any imposed factor, such as temperature, pressure, or concentration gradient, which upsets the balance between the forward and reverse transformation rates.

For example, increasing the input to a system will cause a stress that is relieved by an increase in output generation. Often a reaction or transformation is "driven" to completion based on this principle by adding more energy or materials to shift the equilibrium and generate the desired output. However, this same effect can be achieved by designing transformations in which outputs are continually minimized or removed from the system, and the transformation is instead "pulled" to completion without the need for excess energy or material.

Approaching design through Le Châtelier's principle, therefore, minimizes the amount of resources consumed to transform inputs into the desired outputs. This is well known at the molecular level in chemical transformations such as condensation reactions in which water is eliminated from the product stream to "pull" the reaction to completion. This same technique, though not necessarily in the traditional context, can be applied across design scales.

For example, manufacturing systems can be based on "just-in-time" manufacturing—goods produced to meet end user demand exactly for timeliness, quality, and quantity. This can be more broadly defined such that the end user can be the final purchaser of the product or another process further along the production line. Just-in-time manufacturing requires that equipment, resources, and labor are only available in the amount required and at the time required to do the job. Only the necessary units are produced in the necessary quantities at the necessary time by bringing production rates exactly in line with demand (25).

Planning manufacturing systems for final output eliminates the wastes associated with overproduction, waiting time, processing, inventory, and resource inputs. For example, direct metal deposition produces less final waste than metal casting (26).

Principle 6: Conserve complexity. The amount of complexity that is built into a product, whether at the macro, micro, or molecular scale, is usually a function of expenditures of materials, energy, and time. For highly complex, high-entropy substances, it could be counterproductive and sacrifice value (down-cycling) to recycle the material. High complexity should correspond to reuse, whereas substances of minimal complexity are favored for value-conserving recycling, where possible, or beneficial disposition, when necessary. Natural systems should also be recognized as having complexity benefits that should not be needlessly sacrificed in manufacturing transformation or processing.

Silicon computer chips have a significant level of complexity invested in them, and it may not be efficient to recycle a silicon chip in order to recover the value of the starting materials. The complexity of a brown paper bag also may not, however, warrant the time and energy for collection, sorting, processing, remanufacturing, and redistribution as an intact shopping bag. End-of-life design decisions for recycle, reuse, or beneficial disposal should be based on the invested material and energy and subsequent complexity across all design scales.

By targeting durability and not immortality as a design goal, the risk to human and environmental health at end of life is significantly reduced.

Principle 7: Durability rather than immortality. Products that will last well beyond their useful commercial life often result in environmental problems, ranging from solid waste disposal to persistence and bioaccumulation. It is therefore necessary to design substances with a targeted lifetime to avoid immortality of undesirable materials in the environment. However, this strategy must be balanced with the design of products that are durable enough to withstand anticipated operating conditions for the expected lifetime to avoid premature failure and subsequent disposal. Effective and efficient maintenance and repair must also be considered, so that the intended lifetime can be achieved with minimal introduction of additional material and energy throughout the life cycle.

By targeting durability and not immortality as a design goal, the risk to human and environmental health at end of life is significantly reduced. For example, single-use disposable diapers consisting of several materials, including nonbiodegradable polymers, have represented the single largest nonrecyclable fraction of municipal solid waste (27). Although this product has a short useful lifetime, it remains a significant environmental problem well beyond its targeted and defined need. One solution is a new starch-based packing material, Eco-fill, which consists of food-grade inputs (starch and water) that can be readily dissolved in domestic/industrial water systems at the product's end of life, and is competitive with traditional polystyrene packing (28). By designing durability, but not immortality, into this product, Eco-fill achieves its intended use without long-term environmental burdens.

Another example on the molecular scale is using biologically based polylactic acid to create plastics and fibers instead of petroleum-based polyacrylic acid, which is not biodegradable (29).

Principle 8: Meet need, minimize excess. Anticipating the necessary process agility and product flexibility at the design stage is important. However, the material and energy costs for overdesign and unusable capacity or capability can be high. There is also a tendency to design for worst-case scenarios or optimize performance for extreme or unrealistic conditions, which allow the same product or process to be used regardless of local spatial, time, or physical conditions. This requires incorporating and subsequently disposing and treating components whose function will not be realized under most operating conditions.

The tendency to design an eternal, global solution (e.g., chlorofluorocarbons, PCBs) should be minimized to reduce unnecessary resource expenditures. Drinking water disinfection using chlorine is a good example. Water distributed from a centralized location is treated to ensure that the water remains disinfected to the furthest receiving point. However, water at a shorter distance from the drinking water treatment plant in the system will have higher-than-necessary levels of disinfection byproducts because some dissipate with time. An alternative and potentially more sustainable strategy would be to install actuator and control systems throughout the distribution system that regulate the dose of chlorination (30). This reduces the environmental and human health burdens of chlorine production and the subsequent release of chlorination byproducts, such as trihalomethanes (31).

Although this example does not move toward a nonchlorinated disinfection system, it provides an example of a significant, if incremental, improvement on the current system. This strategy can be applied across design scales to limit the expenditure of underused and unnecessary materials and energy. For example, enzyme catalysts that operate at mild conditions can replace more reactive reagents. Technologies that target the specific needs and demands of end users also offer an alternative to "off the shelf" solutions.

Principle 9: Minimize material diversity. Products as diverse as cars, food packaging, computers, and paint all have multiple components. In an automobile, components are made from various plastics, glasses, and metals. Within individual plastics there are various chemical additives, including thermal stabilizers, plasticizers, dyes, and flame-retardants. This diversity becomes an issue when considering end-of-useful-life decisions, which determines the ease of disassembly for reuse and recycle. Options for final disposition are increased through up-front designs that minimize material diversity yet accomplish the needed functions.

At the process level, this is being done by integrating desired functionality into polymer backbones and thereby avoiding additives at a later stage in the manufacturing process (32). Tailoring polymer properties can have a positive environmental effect in cases in which leaching of additives may be an issue and in cases in which ease of recycling is important.

On the product scale, selected automobile designers are reducing the number of plastics by developing different forms of polymers to have new material characteristics that improve ease of disassembly and recyclability. This technology is currently applied to the design of multilayer components, such as door and instrument panels. For example, components can be produced using a single material, such as metallocene polyolefins, that are engineered to have the various and necessary design properties. Through the use of this monomaterial design strategy, it is no longer necessary to disassemble the door or instrument panel for recovery and recycling (33).

On the molecular scale, this principle is illustrat-

ed with "one-pot" or cascading reactions, or self-assembly processes that replace multistep reactions.

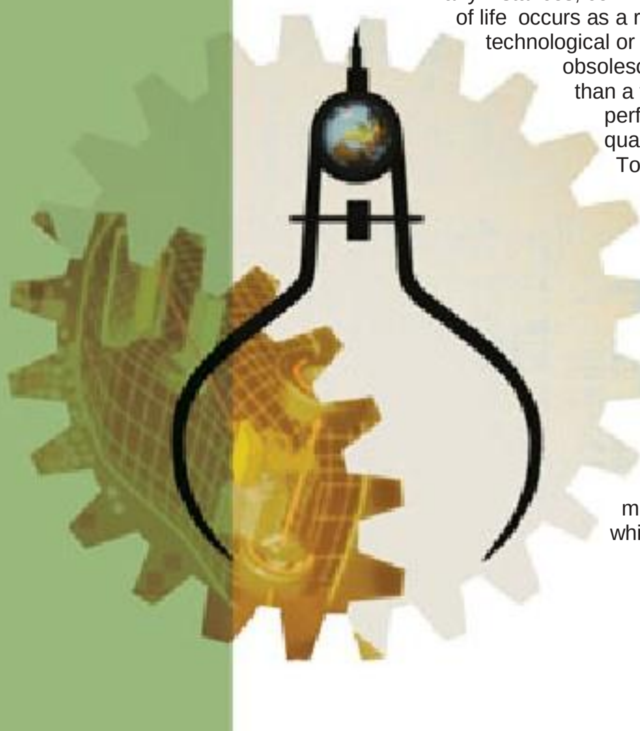
Principle 10: Integrate local material and energy flows. Products, processes, and systems should be designed to use the existing framework of energy and material flows within a unit operation, production line, manufacturing facility, industrial park, or locality. By taking advantage of existing energy and material flows, the need to generate energy and/or acquire and process raw materials is minimized.

At the process scale, this strategy can be used to take the heat generated by exothermic reactions to drive other reactions with high activation energies. By products formed during chemical reactions or through purification steps can become feed-stocks in subsequent reactions. Cogeneration energy systems can be used to generate electricity and steam simultaneously to increase efficiency. In this manner, "waste" material and energy can be captured throughout the production line, facility, or industrial park and incorporated into system processes and final products.

This principle is also illustrated by regenerative braking systems in hybrid electric vehicles. In these systems, heat generated by braking that is typically wasted is captured, reversing the electric motor. This turns the motor into an electric generator, creating electricity that is fed back into a battery and stored as energy to propel the vehicle. Integrating the drive train with the regenerative braking system reduces the vehicle's fuel demands and significantly improves fuel efficiency (34).

As this example demonstrates, it is important to consider the availability of energy and material for a product or process. Energy inputs from sources, such as waste heat from adjacent processes or incorporation of already existing materials, may significantly benefit the life cycle, reducing the need for raw materials and energy acquisition and requiring less processing and disposal.

Principle 11: Design for commercial "afterlife". In many instances, commercial end of life occurs as a result of technological or stylistic obsolescence, rather than a fundamental performance or quality failure To reduce Waste components that remain functional and valuable can be recovered for resuse and/or reconfiguration. This strategy encourages up-front modular design, which reduces the need for acquiring and processing raw materials by allowing the next-generation designs of products, processes, or systems to be based on recovered components with known properties.



By incorporating commercial "afterlife" into the initial design strategy, rather than as an afterthought at end of life, the value added to molecules, processes, products, and systems could be recovered and reused at their highest value level as functional components. This case is most compelling when end of life is premature and not a fundamental quality failure, as in the case of personal electronics. Cellular telephones, personal digital assistants, and laptop computers are often retired as styles change or technology advances (35); however, the physical components are still fully functional and therefore valuable. Designing products with components that can be recovered would significantly reduce end-of-life burdens and manufacture of duplicate components in the next-product generation. For example, approximately 90% of Xerox equipment is designed for remanufacture (36). Converting old industrial buildings to housing is an example at the systems scale.

Principle 12: Renewable rather than depleting. The nature of the origin of the materials and energy inputs can be a major influence on the sustainability of products, processes, and systems. Whether a substance or energy source is renewable or depleting can have far-reaching effects. Every unit of finite substance used in a consumptive manner incrementally moves the supply of that substance toward depletion. Certainly, from a definitional standpoint, this is not sustainable. In addition, because virgin substances require repetitive extractive processes, using depleting resources causes ongoing environmental damage.

Renewable resources, however, can be used in cycles in which the damaging processes are not necessary or at least not required as often. Biological materials are often cited as renewables. However, if a waste product from a process can be recovered and used as an alternative feedstock or recyclable input that retains its value, this would certainly be considered renewable from a sustainability standpoint. Examples include recovering biomass feedstocks, treating wastewater with natural ecosystems (37), and biobased plastics.

Although it is certainly true that all human processes and actions will have some impact on the environment, minimizing those actions that irreversibly, significantly alter the sustainable supply of a resource can lead to the design of more sustainable products, processes, and systems.

Final points

Innovation in design engineering has resulted in feats ranging from the microchip to space travel. Now, that same innovative tradition must be used to design sustainability into products, processes, and systems in a way that is scalable. By using the 12 Principles of Green Engineering as a framework, the conversation that must take place between designers of molecules, materials, components, products, and complex systems can occur using a common language and a uni-

The principles are a set of methodologies to accomplish the goals of green design and sustainability.

versal method of approach. The principles are not simply a listing of goals, but rather a set of methodologies to accomplish the goals of green design and sustainability.

Because of practical, logistical, economic, inertial, and institutional reasons, it will be necessary in the near term to optimize unsustainable products, processes, and systems that are currently in place. This is an important short-term measure, and the green engineering principles provide a useful framework for accomplishing this optimization. However, through re-engineering of entire systems (e.g., personal transportation systems), greater degrees of freedom with potential benefits for sustainability are obtained, and therefore, the principles become more essential. Ultimately, a redefining of the problem, from the molecular to the systems level, is where fundamental and even inherent sustainability can be achieved. This is where the 12 principles are most powerful.

Although each principle can be demonstrated at each scale, the 12 principles have neither been implemented systematically nor across all scales. Systematic integration of these principles is key toward achieving genuine sustainability in the design of molecules, products, processes, and systems, for the simultaneous benefit of the environment, economy, and society, and the ultimate goal of sustainability.

Acknowledgment

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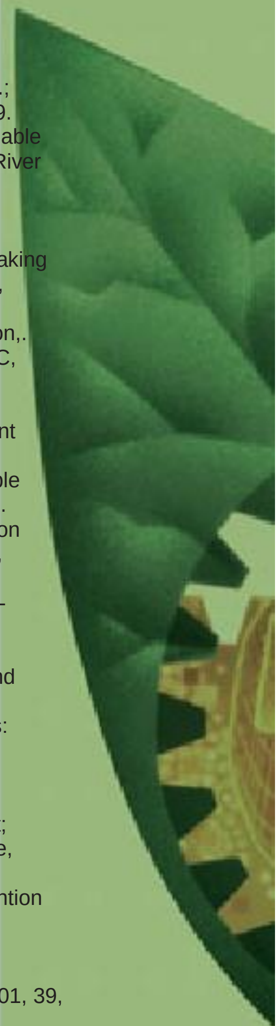
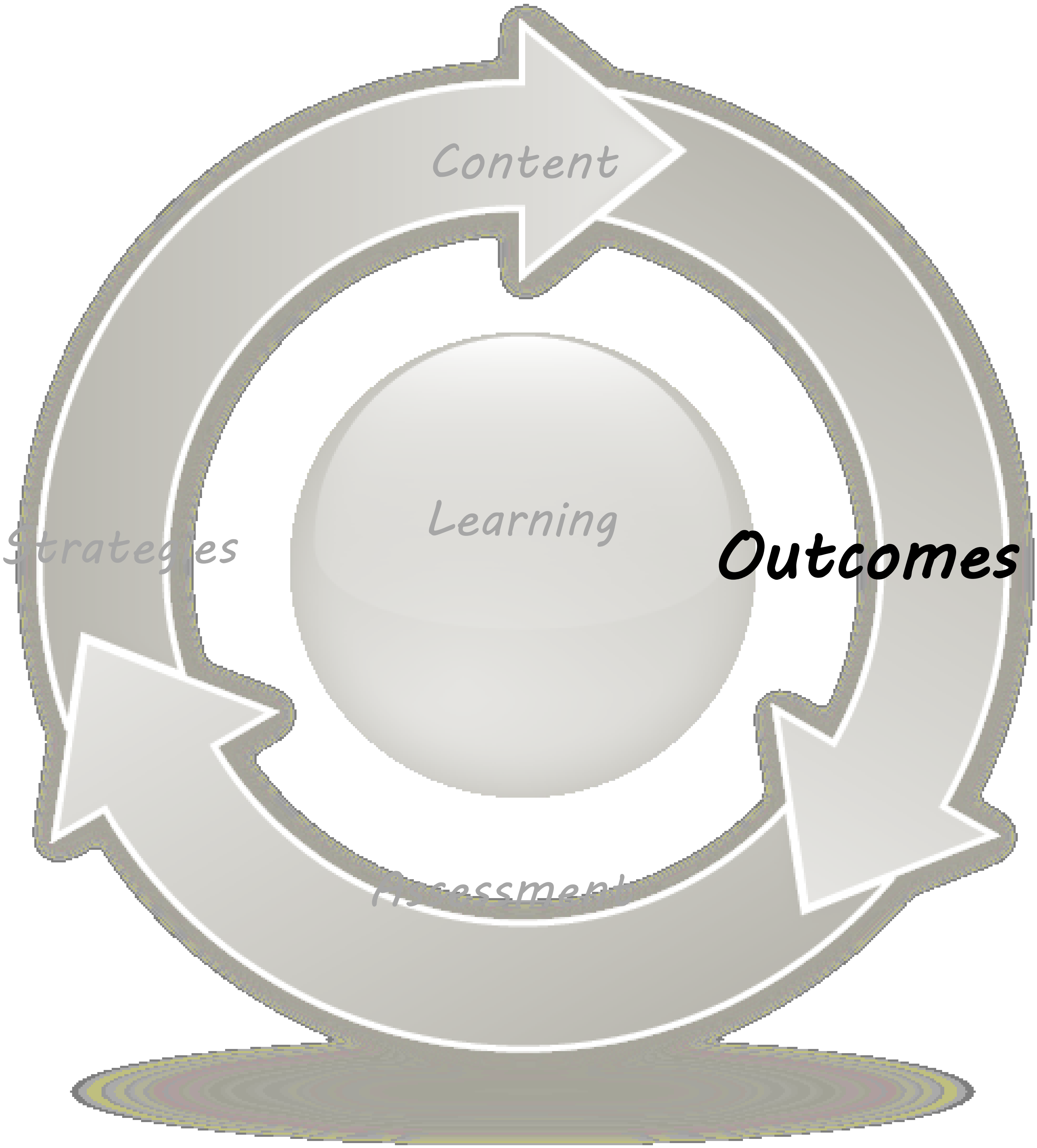
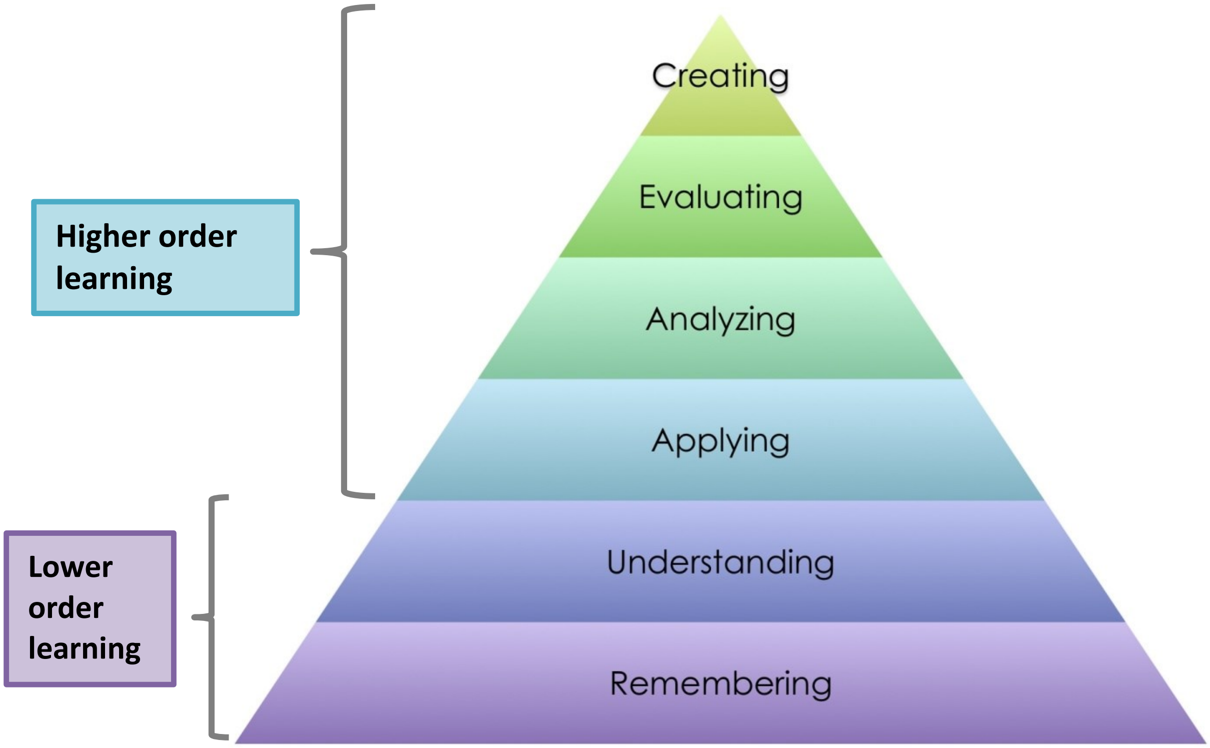



Content
Learning
Outcomes

Levels of Learning (Bloom's Taxonomy[1])



[2]

LEVEL	Definition
Remembering	Recalling information
Understanding	Identifying examples of a given term, concept, or principle. Interpreting the meaning of an idea, concept or principle.
Applying	Using information, rules and procedures in concrete situations.
Analyzing	Breaking information into parts to explore patterns and relationships. Analyzing charts, data to support conclusions.
Evaluating	Making judgments based on criteria and standards.
Creating	Generating new ideas or products.

[1] Anderson, L.W., & Krathwohl, D. R. (Eds.). (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York: Longman.

[2] Image from Purdue University, Reflections on Teaching and Learning Webpage: http://blogs.itap.purdue.edu/learning/2012/05/04/review-of-idc-tools-to-assess-blooms-taxonomy-of-cognitive-domain/

Outcomes

Levels of Thinking[3]

Remember		
Retrieve relevant knowledge from long-term memory.	Instructional Objectives	Key Terms (VERBS)
Remembering requires the recall or recognition of specific elements in a subject area in a way similar to how they were learned. In its simplest form, this includes knowledge of the terminology and specific facts associated with an area of subject matter. At a more complex level it means knowing the major sub-areas, methods of inquiry, classifications and ways of thinking characteristic of the subject area, as well as its central theories and principles. Testing for knowledge objectives requires that students offer the answer out of memory (fill-in the blank questions), or choose items which they select from a set of given alternatives (multiple choice questions).	Knows common terms Knows specific terms Knows methods and procedures Knows basic concepts Knows principles Knows how to carry out algorithms & simple computations (no decision-making)	define, describe, identify, label, list, match, name, outline, recall, recognize, reproduce, state, compute

Understand		
Determine the meaning of instructional messages, including oral, written, and graphic communication.	Instructional Objectives	Key Terms (VERBS)
Understanding goes one step beyond the simple remembering of material. It requires that the learner differentiate essentials of the message from aspects unimportant to the message. Understanding suggests that the learner comprehends or internalizes and systematizes the knowledge. Understanding may be shown by translating material from one form to another (words to numbers), by interpreting material (explaining or summarizing), or by extrapolating from the literal communication itself to determine implications, inferences, extensions or conclusions. The student is asked to translate, comprehend, or interpret information based on prior learning.	Chooses relevant information Understands facts and principles Interprets verbal material Interprets charts and graphs and problems Knowledge of rules, principles and generalizations Able to follow a line of reasoning	interpret, exemplify, select, classify, compare, convert, explain, extend, generalize, identify, predict, infer, paraphrase, rewrite, summarize, distinguish, give an example

[3] Champlain College, Quebec: PAREA Research Team, Winter 2004.

Apply		
Carry out or use a procedure in a given situation.	Instructional Objectives	Key Terms (VERBS)
Applying refers to the ability to use or apply learned material in new and concrete situations. This may include the application of such things as rules, methods, concepts, principles, laws, and theories. The student is asked to select, transfer, and use data and principles to complete a problem task with a minimum of direction.	Applies concepts and principles to new situations Applies laws and theories to practical situations Solves routine mathematical problems Constructs charts and graphs Demonstrates correct usage of a method or a procedure Able to analyze	execute, implement, change, compute, discover, demonstrate, manipulate, modify, operate, predict, prepare, produce, relate, show, solve, use, construct

Analyze		
Break material into its constituent parts and detect how the parts relate to one another and to an overall structure or purpose.	Instructional Objectives	Key Terms (VERBS)
Analyzing is the breakdown of a communication into its component ideas or parts so that the relative hierarchy of the ideas is made clear and/or the relations between the ideas are made explicit. Learning outcomes here represent a higher intellectual level than comprehension and application because they require an understanding of both the content and the structural form of the material. The learner must be able to identify the important elements in a communication, and recognize the structure, which holds the communication together. The student is asked to distinguish, classify, and relate the assumptions, hypotheses, evidence, conclusions, and structure of a statement or a question. Analysis refers to what is called logic, induction and deduction, and formal reasoning.	Classifies words and statements according to a given analytic criteria Perceives and infers relationships between elements Discovers similarities & differences Discerns a pattern, order, or arrangement of materials Infers particular qualities or characteristics not directly stated in the reading or lecture Solves non-routine problems	classify, analyze, distinguish, organize, structure, compare, contrast, categorize, order, differentiate, outline, separate, subdivide, breakdown

Evaluate		
Make judgments based on criteria and standards.	Instructional Objectives	Key Terms (VERBS)
Evaluating is the making of judgments about the value of ideas, works solutions, methods, or material. It involves the use of criteria as well as standards for appraising the extent to which particulars are accurate, effective, economical, or satisfying. The judgments may be quantitative or qualitative, and the criteria may be either self-determined or provided externally (Bloom, 1956, p.195). Evaluation requires that the student makes judgments about something he or she knows, analyzes, and synthesizes, and so forth, on the basis of criteria which can be made explicit. Evaluation has two steps. The first step is to set up appropriate standards (criteria) and the second is to determine how closely the object or idea meets these standards.	Judges the logical consistency of written material Judges the adequacy with which conclusions are supported by data Judges the value of a work (art, music, writing) by use of internal criteria Judges the value of a work (art, music, writing) by use of external standards of excellence	critique, check, appraise, compare, conclude, contrast, criticize, describe, discriminate, explain, justify, interpret, relate, summarize, support

Create		
Create something new based on some criterion.	Instructional Objectives	Key Terms (VERBS)
Creating is putting together elements and parts so as to form a whole. This involves the process of working with pieces, parts, elements, etc., and arranging and combining them in such a way as to constitute a pattern or structure that was not there before. Therefore, students create, integrate, and combine ideas into a product, plan, or proposal that is new to them. This cognitive process refers to what is called creative or divergent thinking.	Writes a well-organized theme Gives well-organized presentations Proposes a plan for an experiment Integrates learning from different areas into a plan for problem solving Formulates a new scheme for classifying objects or events, or ideas Generates missing links Combines parts to form a whole Develops a course of action Generates a high-level conclusion Explains why	combine, compile, compose, create, devise, design, explain why, generate, modify, organize, plan, produce, rearrange, reconstruct, relate reorganize, revise, rewrite, elaborate, give reasons or support

Example of Bloom's Taxonomy in Engineering

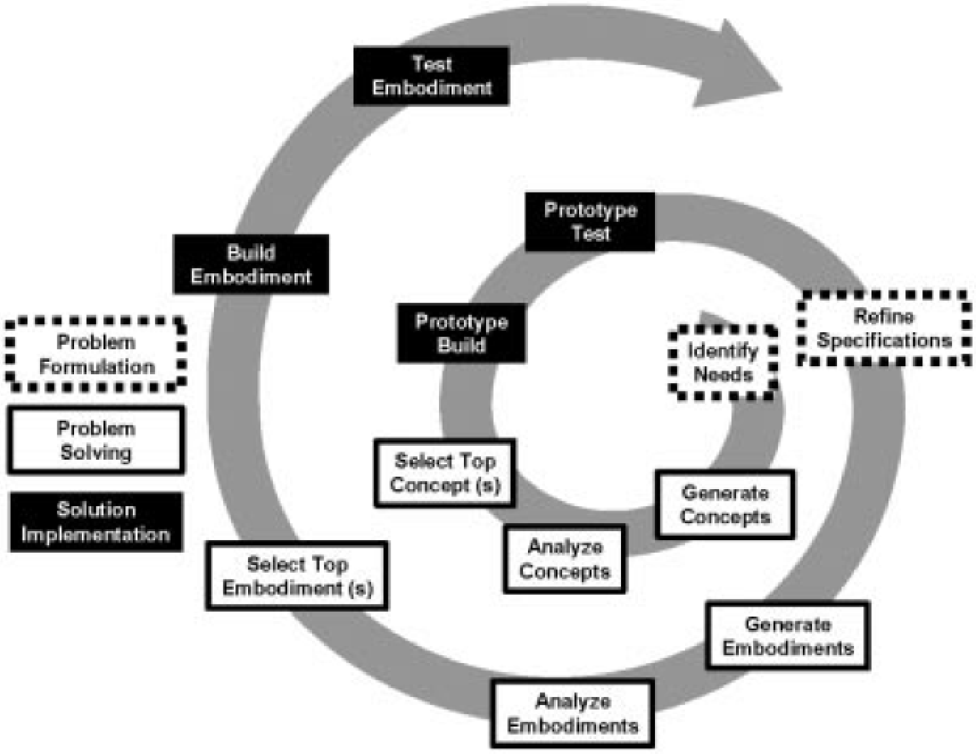


Fig. 1. Engineering design spiral.

At the end of this course students will be able to:

Remembering: Remember the spiral figure in Fig. 1.

Understanding: Explain Fig. 1 and each phase represented in it

Applying: Implement the process depicted in Fig. 1

Analyzing: Select the appropriate steps in the design process

Evaluating: Compare the process in Fig. 1 with other design processes and explain the strengths and weakness of each process

Creating: Form an entirely new design process.

References / Resources

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Exercise 2: What are the learning outcomes of my course?

Step 1 (15 minutes)

- Review your concept map.
- Develop the sustainability learning outcomes for the course:

  What will students learn, in terms of sustainability, as a result of participating in the course?
  What knowledge, skills and values, in the field of sustainability will they develop?
  What should they be able to do or think about differently?

- Please keep in mind the following questions as you develop and review the outcomes:

  Is the learning outcome:

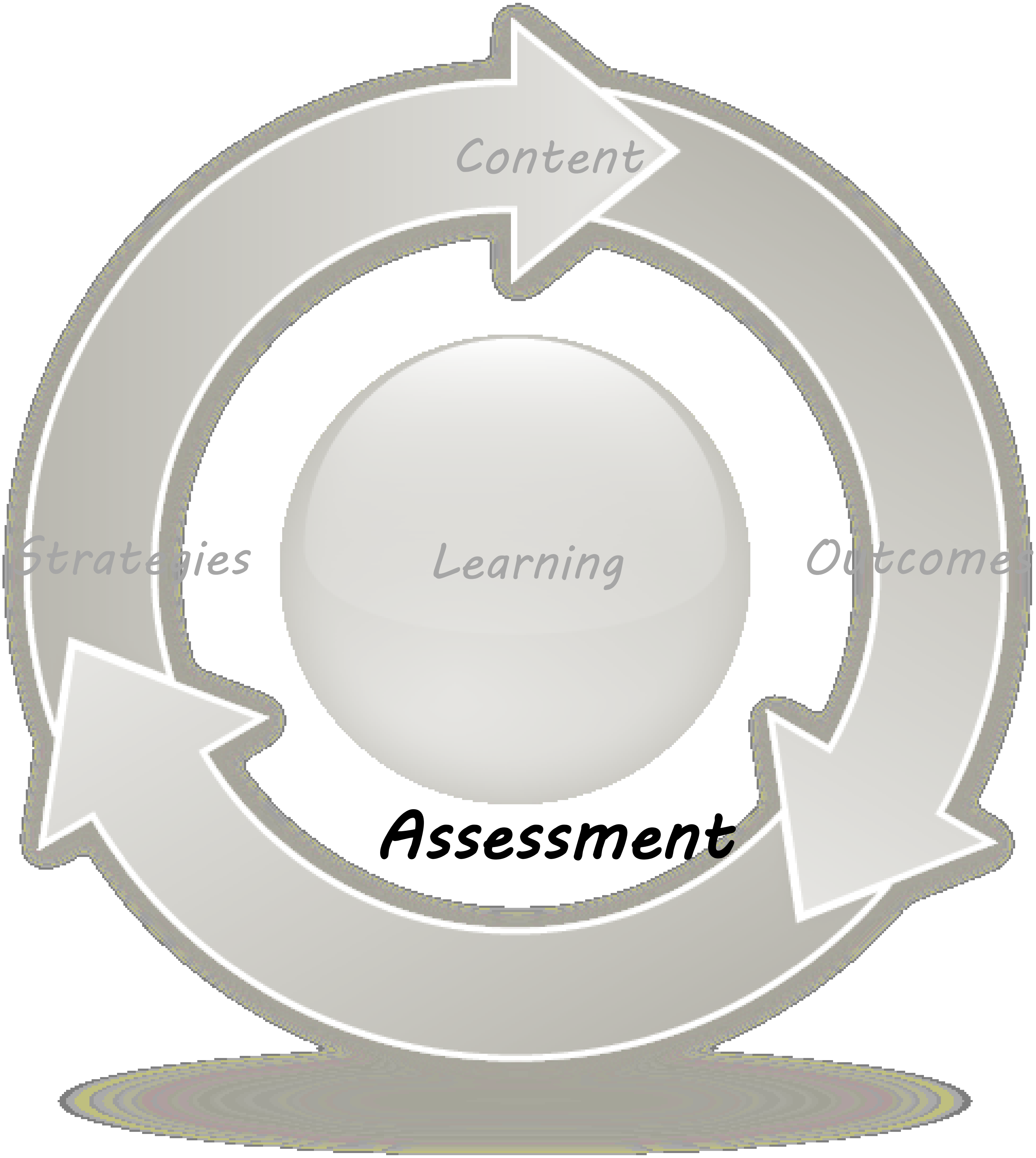
  1. learner oriented (focused on what students will learn)?
  2. potentially measurable?
  3. clear and concise?
  4. related to your concept map?
  5. appropriate to the characteristics / level of your students?

Step 2 (15 minutes)

- Pair with another participant and exchange feedback on your learning outcomes. Use the questions above to guide your discussion.

Step 3 (10 minutes)

- Revise your learning outcomes with the feedback received.


Content
Strategies
Learning
Outcomes
Assessment

Assessment

Guiding questions for developing an assessment plan for your course

1. Are methods aligned with outcomes? Does the language used make the alignment explicit?
2. Is the weighting of the different methods appropriate in relation to the importance of the outcomes and the time that students will spend on learning?
3. Are the assessment methods distributed over the course to reduce stress and provide feedback to learners on progress towards achieving the outcomes?
4. Do you provide opportunities for students to practice and get feedback on the tasks on which they will be graded?
5. Are a range of methods used, including alternative and informal, to support different kinds of learners?
6. Do you use an assessment rubric or scoring guide to improve consistency of grading? Do you share the rubric with your students to help them understand your expectations?
7. Is the assessment plan realistic; i.e. not too much work for you and your students?
8. Are the students given choices or options if possible?

Examples of Assessment Methods[4]

Method	Purpose This method is effective for…	Description	Example
Background Knowledge Probes[5]	- Determining effective starting points / appropriate levels of instruction for a given subject or class - Focusing students' attention on relevant material	A background knowledge probe asks for basic, simple responses from students prior to beginning to study a new concept. Clickers (Student Response Systems) can be a quick and thorough method of tabulating student responses to multiple choice questions in larger classes. Other possibilities include circling, showing of hands, or short answer questions.	1. In a Law course: What are the key features of a tort?
Cases	Assessing: - Analytical skills - Decision making skills - Problem solving skills - Application of knowledge - Evaluative skills Developing self-directed learning	A case is a description of an actual situation that requires students to make decisions or solve problems about specific issues.[6] Good cases have the following features: - Tell a real or believable story - Allow for numerous interpretations of motives - Complex enough to raise interesting questions and responses, yet sufficiently clear and concise to avoid overwhelming students. - Encourage students to think and take a position on an issue related to learning goals,[7] Cases provide scenarios that students may encounter when they would need to use the information learned, thereby contextualizing their learning.	1. In a medical course, students are asked to match findings to interventions applied, and describe their implications for the patient. 2. In a banking course: The instructor presents students with numerous loan applications from entrepreneurs. Students recommend which loan applications will be approved or declined, and why.

Please cite as follows: Teaching and Learning Services. (2011). *Examples of assessment methods*. Montreal: Teaching and Learning Services, McGill University.
[5] Barkley, E.F., Cross, K.P., & Major, C.H. (2005). *Collaborative Learning Techniques*. San Francisco: John Wiley and Sons.
[6] Bean, J. (2001). *Engaging ideas: The professor's guide to integrating writing, critical thinking, and active learning in the classroom.* San Francisco: Jossey-Bass.
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Method	Purpose This method is effective for…	Description	Example
Closing Summary	- Ascertaining whether students have identified or grasped key topics - Helping students reflect on their learning	A closing summary lists key concepts or ideas discussed, and is used at the end of a class period or unit. Students write a summary of main ideas discussed during class. Students can compare their summaries in pairs to build upon one another's understanding of the material. The professor reviews the lists to see if students identified and grasped key topics presented. The professor may selectively collect the lists and summarize the main points, addressing misconceptions at the next class. Alternately, students can summarize the previous class session at the beginning of the next one, to ensure continuity between class periods.	1. What are three key points or "take-aways" of today's class? 2. What did you find most interesting? What did you find least interesting? What did you want to learn more about? 3. If you were to make two exam questions that consider the main points from today's material, what would they be? How would you answer those two questions?
Direct Observation	- Assessing skills and performance - Giving individualized feedback	During direct observation, the instructor or peers watch and take notes as students carry out prescribed tasks. This may be appropriate for assessing teamwork skills, presentations, in clinical/simulation situations, or during a stage. Students receive constructive feedback that is tailored to their performance.	1. At the end of a stage in elementary school education, an instructor observes and evaluates students' teaching skills.
Formal Writing Assignments[8]	Assessing - writing skills - reflective skills - understanding - synthesizing - critical thinking - evaluative skills - research skills	Formal writing can take many forms such as research papers, short essays, critical reviews, personal reflections, reports, or imaginary writing. Consider the learning goals and the type of thinking that you want your students to demonstrate. Provide clear guidance regarding the task, format expectations, and criteria for evaluation. Using rubrics to help the grading process is recommended.	1. Students in U.S. History II read primary source materials written by individuals involved in the drafting of the Articles of Confederation, the Constitution, and the Bill of Rights. Students then write an essay on the readings.[9]

[8] Bean, J. (2001). *Engaging ideas: The professor's guide to integrating writing, critical thinking, and active learning in the classroom.* San Francisco: Jossey-Bass.
[9] Jefferson College. (2009). The Assessment Update. Retrieved on April 26th, 2013 from http://vega.jeffco.edu/szak/handouts/CorrectedAssessmentNewsletterFeb09.pdf

Method	Purpose This method is effective for…	Description	Example
Focused Listing	- Identifying students' prior knowledge or attitudes - Summarizing student learning about a specific topic	Students recall what they know about a subject by creating a list of terms or ideas related to it. Students generate a list based on a given topic, either individually or in groups. Students may then share their ideas and identify the most important points in small groups. This strategy need not take more than a few minutes, and can be used before or after instruction. Students can make a focused list prior to the discussion and then add to the list (correcting any prior misconceptions) at the end of the class period.	1. In an educational psychology course, students give examples of defining characteristics of Piaget's stages of cognitive development. 2. In a political science course, students identify the pros and cons of a government's proposed course of action currently in the news.
Learning Logs / Diary	- Assessing reflection skills - Keeping track of processes on a regular basis - Helping students clarify their experiences and connect them with their learning	Students reflect about their experiences or new knowledge gained in a pre-determined format. Formats may range from an unstructured account of each day to a structured form based on tasks. Clarify purpose, scope and expectations for journal entries. Logs/dairies can be time-consuming for students. Some training in reflection is recommended. Have students submit their journals regularly for feedback. Structured peer evaluation is an option.	1. In a Shakespeare course, students are asked to write personal, critical responses to his plays. 2. In a course on clinical practice, students reflect upon their stage or other experiences with patient care. Decisions made are explained with a rationale, and outstanding questions are posed for feedback.

Method	Purpose This method is effective for…	Description	Example
Microthemes	- Developing ability to write concisely - Developing students' problem-solving skills - Promoting growth in reflection and other thinking skills	Students reflect upon a question or prompt and, in lieu of writing a lengthy essay, submit a ½ page response that meets pre-established criteria. This strategy is based on the expectation that a short writing assignment is preceded by a significant deal of thought. Microthemes may be used for writing summaries (e.g. of journal articles), to develop a thesis statement, to make sense of discrete, related data, or to propose a solution to a problem. This technique is appropriate for both larger and smaller classes, and may be used as ungraded or low-stakes assessment. Using a simple rating scale, instructors can grade 30-50 microthemes per hour.[10]	1. Students summarize a journal article, identifying major and supporting points and key conclusions or take-aways. 2. Students respond to the following prompt, justifying their response with reference to appropriate resources and using strong reasoning skills: *The performance of a mutual fund (is/is not) superior to the performance of the stocks chosen by the average investor.*
Muddiest Point	- Reflecting upon aspects of the course material that were the least clear to students.	Students write down what was most confusing to them after a class period. Students should be very specific in identifying the source or issue of confusion. "Muddiest point" feedback can be used to create new ways to discuss those points that multiple students found to be unclear: The instructor can begin the next class by reviewing selected "muddiest points", or students can attempt to answer one another's questions.	1. What was the "muddiest point" of the material discussed today? 2. Write one thing that wasn't clear to you from today's course material. Why do you think this was confusing?
Multiple Choice Questions (MCQs)	- Ascertaining understanding - Assessing students' analysis, problem solving and evaluative skills	MCQs sample a wide range of knowledge quickly by presenting students with a variety of possible responses (usually 3-5) to a question or scenario. Students choose the best response(s). MCQs that assess higher-order thinking skills are time-consuming to create but efficient to grade. A team of assessors working with the same learning outcomes can brainstorm and produce several questions in a couple of hours. Questions should be clearly worded, and ideas may be developed or compiled with input from relevant internet or textbook sources.	1. A medical multiple choice question may ask "What is the most likely diagnosis?" or "What pathogen is the most likely cause?" in reference to a brief case study presented. Students have then the opportunity to choose an answer among a number of possibilities.[11] a.

[10] Bean, J., Drenk, D., & Lee, F. (1982). Microtheme strategies for developing cognitive skills. *New Directions for Teaching and Learning: Teaching writing in all disciplines*, 12, pp. 27-38.
[11] Direct quotation from Wikipedia database. (n.d.) Multiple Choice. Retrieved on April 26th 2013, from http://en.wikipedia.org/wiki/Multiple_choice

Method	Purpose This method is effective for…	Description	Example
Objective Structured Clinical Examinations (OSCEs)	- Assessing student competency in clinical skills - Developing students' communication and practical skills	OSCEs are a performance-based assessment method measuring candidates' clinical competence. Students interview and recommend treatment of "patients" demonstrating pre-determined symptoms. Although these can be challenging to design and organize, they are easy to score and to provide feedback upon. They can be used at the beginning of a course to estimate key practical skills or (more often) towards the end of a course to provide feedback or to test performance against outcomes. Several assessors are required at one time. The clinical competence to be tested is broken down into its various components, which are assessed in turn at numerous stations.[12]	1. Example Candidate Instructions: Your next patient is Barbara Morley, a 35-year-old woman who is here today with abdominal pain. During the next 14 minutes, obtain a relevant history of her presenting problem and perform a focused physical examination. Please be sure to answer any questions the patient might have. The ten-minute warning buzzer will indicate you have four minutes remaining.[13] 2. Examples of competencies tested at OSCE stations: 1) Obtain a focused relevant patient history; 2) Conduct a focused and relevant physical exam; 3) Conduct a focused mental status exam (elicit mood, suicide risk, energy level, memory etc.); 4) Interpret x-rays, lab results, MRI images etc.; 5) Suggest a differential diagnosis; 6) Detail an initial investigation or management plan.[14]

[12] Harden, R.M., & Gleeson, F.A. (1979). Assessment of clinical competence using an objective structured clinical examination (OSCE). *Medical Education, 13*, 41-54.
[13] Direct quotation from Clinical Assessment for Practice Program. The Objective Structured Clinical Examination (OSCE): Clinical Format. Retrieved on August 9th 2011, from http://www.capprogram.ca/osce-format.htm
[14] Direct quotations from the Association of International Physicians and Surgeons of Ontario, Information Resource for International Medical Graduates. Retrieved on August 9th 2011, from http://testunix.mediaforce1.com/imginfo/img/exams/exam-formats.htm#3

Method	Purpose This method is effective for…	Description	Example
(One-)Minute Paper[15]	- Briefly exploring ideas before discussion - Reflecting and refocusing during a class - Bringing closure to a session by reflecting on issues discussed during the class	A "Minute Paper" is a very short (1 to 5 minutes) in-class writing activity in response to a question, prompting students to reflect on relevant issues that they have learned about during the session. Questions may elicit students' interest, perceived relevance, analysis, conceptual connections, etc. Emphasize content over form, so that students focus on expressing their ideas given the time limitation. This assessment method can be implemented at the beginning, in the middle or at the end of a class.	*Interest:* What do you think was the most stimulating idea discussed during class today? *Gauging relevance:* What idea strikes you as something you could put into practice? *Attitudes/Opinions:* Would you agree or disagree with the following statement: . . .? Why? *Analysis:* What did you see as the main objective of today's discussion?
One-Sentence Summary	- Ascertaining how concisely, completely, and creatively students can summarize information on a given topic - Synthesizing and integrating information	This technique challenges students to answer the questions "Who does what to whom, when, where, how, and why?" (WDWWWWHW) about a given topic. Students summarize the information within the grammatical constraints of a single sentence. Give students clear directions on the One-Sentence Summary before announcing the topic to be summarized. Select a topic or work that the students have recently studied in the course. Have students answer the questions above in relation to that topic. Students should turn their answers into a grammatical sentence that follows the WDWWWWHW pattern. With this summarizing technique, students` responses can be compared quickly and easily.	1. In a political science course: During the class prior to the assessment, the instructor explains the technique and works through an example with the students. The week after, at the end of the lecture, students have ten minutes to complete the exercise, summarizing the Iran-Contra affair.

[15] Description and examples adapted from On Course Workshop. (n.d.). The one-minute paper. Retrieved on April 26th 2013, from http://www.oncourseworkshop.com/awareness012.htm

Method	Purpose This method is effective for…	Description	Example
Orals	-Testing communication, understanding, capacity to think quickly under pressure and knowledge of procedures	An oral evaluation evaluates the student's ability to verbally demonstrate their understanding of a specific topic/concept. Orals may be in a presentation, interview or examination format. Begin by providing a clear and detailed description of the assessment task and criteria, to reduce stress related to uncertainty. Model what students will need to do and provide opportunities for practice and feedback so students become accustomed to thinking quickly under pressure. Take notes during the oral assessment, and mark immediately afterwards. The duration of the presentation or interview should be consistent with expectations of the depth or complexity of topic coverage.[16]	1. To obtain their Quebec teaching certification, students in education must pass an oral exam where they have to summarize the content of one article (among three provided in advance), then answer questions from the evaluators.
Portfolios	- Ascertaining reflective and synthesizing skills - Providing information on students' development - Engaging students in various aspects of coursework	A portfolio contains samples of a learner's work collected by the learner over a period of time, that taken together demonstrates the learner`s successful achievement of a specified outcome. Portfolios come in different forms and may include formal written work, personal reflections, feedback on the learner's performance, visuals, artifacts, etc. Prior to introducing a portfolio assignment, determine how the portfolio will be evaluated and create grading rubrics that reflect expectations for the final product.	1. Students in education create portfolios to demonstrate their teaching competency. These include a teaching philosophy, examples of classroom materials developed, and other artefacts that demonstrate their attainment of the standards for initial teacher certification. 2. Students in electrical engineering create online portfolios to demonstrate their mastery of course concepts. These may include reports, photos and 3-D models from projects, and other artefacts.

[16] Joughin, G. & Collom, G. (n.d.). Oral Assessment. Higher Education Academy. Retrieved on April 26th 2013, from http://www.heacademy.ac.uk/assets/documents/resources/resourcedatabase/id433_oral_assessment.pdf

Method	Purpose This method is effective for…	Description	Example
Poster Sessions	- Assessing students' understanding of key course topics, issues, or ideas. - Assessing communication and synthesis skills	A poster session allows students to demonstrate their knowledge both visually and orally. Students create posters and are prepared to provide explanations and answer questions about their topic. The poster session may be intended for the students and professor only, for others in the department, or open to the public. Determine the topic, content and design parameters, and how exhibits should be displayed. Directions and evaluation criteria should be provided to students well in advance (evaluation rubrics may be useful).	1. In a course on technology in secondary education, students present posters on various social media applications that can be used to enhance student engagement and a sense of community in the classroom. Students have time to answer questions about their own posters, as well as to peruse their classmates' work.
Pre-and Post-Quizzes	- Determining student learning gains over the course of a single class period - Gathering information about students' prior knowledge	Pre- and post-quizzes allow instructors and students to immediately see the information that students have learned, by comparing their knowledge at the beginning and end of a class period or unit. Create a 1-page quiz that covers the primary focus of your session. Photocopy the quiz onto both sides of a sheet of paper for each student. Have students take the quiz at the beginning of the session, then set it aside. When the students take the same quiz (other side of the paper) at the end of the lesson, they will see what they have learned instantly, thus provides timely feedback on their learning. Ensure that sufficient time is allotted to convey the correct answers at the end of the session and to answer any questions that arise. Alternately, give a handout or send a follow-up e-mail with the correct responses.	1. In an introductory biology course, students are asked to put the steps for meiosis in order and label the structures both prior to and following the lecture.

Method	Purpose This method is effective for…	Description	Example
Presentations	- Gauging preparation, understanding, knowledge, capacity to structure information, and oral communication skills - Providing feedback from peers as well as from the instructor - Verifying how students respond to questions and manage discussion	Presentations are a form of oral evaluation in which single students or small groups share their knowledge with classmates and the professor. They often contain a visual component (e.g. PowerPoint slides, handouts) and often include time for questions from the audience. Like poster sessions, presentations can be assessed by the professor, peers and by the students presenting. Discuss expectations for presenters and audience members. Provide students with a rubric (or develop criteria as a class), and review how to provide constructive feedback to peers. Low-stakes, practice presentations to smaller groups of peers may be appropriate. A video-recording can also be made to allow the evaluator or student to review their presentation afterwards.	1. Students in an archives / records management course present the results of their research on various metadata descriptive standards (e.g. Dublin Core, Encoded Archival Description (EAD)), including examples of what the fields and metadata look like in both HTML and reader views. 2. Students in a human anatomy course give presentations on the vascular and lymphatic systems, including multimedia that demonstrate how these systems work.
Problems	- Developing communication, problem-solving, and self-directed learning skills - Ascertaining whether students are able to apply theoretical concepts or content to real-life problems.	Problems are scenarios or challenges to which students develop a solution given the information presented. They may be “open” (where numerous possible solutions are accepted) or “closed” (where students must decide upon the one possible solution). They often contain written, numerical or graphical components. Grading time varies with the complexity of the problem; rubrics can be useful in reducing grading time and clearly stating expectations. Encourage students to reflect upon how different conditions might affect their response, or approach the same problem from a different point of view. (For instance, in the first example given, they might propose solutions from the perspective of an organic farmer, a pesticides company, and a community-supported agriculture organization.) For collaborative problem-solving, groups should be chosen carefully, to facilitate students’ interactions and promote a productive group dynamic.	1. In a plant science course: Numerous farmers in the Eastern Townships report that their tomato plants are stunted and withered. What would you propose as the cause of this unhealthy appearance? What would you suggest that the farmers do to approach this problem? Using the resources, consider the context, discuss in your team, and justify your response. 2. A calculus teacher decides to assess students’ problem-solving skills by giving homework where students have to solve four calculus problems (instead of the usual five). The students then select one of the problems and document their solution, explaining, step by step in complete sentences, how they solved it.

Method	Purpose This method is effective for…	Description	Example
Projects	- Developing practical, analytical, and interpretative skills - Demonstrating students' understanding, knowledge, and skills in real/simulated situations - Allowing students to reflect upon their learning	Projects take a variety of forms, but generally include an agreed-upon end product that demonstrates students' achievement of desired outcomes. (e.g. presentation, report, essay, website, etc.) Projects can be successfully carried out by individual students or in groups; the number of people should be taken into consideration when establishing criteria and workload expectations. Group projects can provide an opportunity for developing teamwork skills and leadership. Learning gains can be high. Although marking for grading can be time-consuming, marking for feedback can be complemented or reduced through peer and self-assessment and presentations.	Final projects can be formulated as questions for students to explore: 1. Should all patients receive iron and vitamin C following knee and hip replacement? If not, which patients are most likely to benefit from these supplements? 2. How can one determine if the risks of warfarin for stroke prevention in elderly patients with atrial fibrillation outweigh the benefits? 3. Is there an age cut-off beyond which routine cancer screening should not be offered to elderly patients? 4. Does treatment of vitamin B12 deficiency improve cognition in the elderly?[17]

[17] Examples are direct quotations from University of Virginia School of Medicine. (2011). Final project example. Retrieved on April 26th 2013, from http://www.medicine.virginia.edu/clinical/departments/medicine/grad-ed/geri/welcome-students-geriatric-clerkship-orientation/assignments/FinalProjectExamples-page/

Method	Purpose This method is effective for…	Description	Example
Questions	- Actively involving students in class as they apply concepts and content learned - Assessing student comprehension of content	The instructor poses thoughtful questions to the entire class, small groups or individual students. Questioning and classroom discussion provide opportunities for enhancing students' knowledge and understanding. Questions should relate to learning outcomes and be thoughtful and reflective; simple, factual questions are not enough. Students need sufficient time to think and respond. Think about instruction in terms of the questions you hope are being answered: "If this session is the answer, what is the question?" and phrase your question prompts accordingly.	1. In a course on small business management and practice, the instructor asks students how they would attract new clients, given a limited budget. She specifies that responses should make reference to concepts discussed in class or in the readings. 2. A psychology professor wants to determine whether students have applied lessons learned in the survey course to their lives. The instructor asks: "Have you tried to apply anything you've learned in this unit on human learning to your own life? If 'yes', please provide detailed examples. If 'no', please explain briefly why you have not tried to apply what you learned in this unit." During the following class meeting, the professor summarizes the results and asks students to share their applications.

Method	Purpose This method is effective for…	Description	Example
Readiness Assessment	- Assessing students' comprehension of pre-class readings -Making students responsible for their learning and for contributing to a team	Readiness assessment is an assessment method that combines individual and small-group work to generate accountability for pre-class readings, strengthen teamwork skills, and focus the class section on the key topics to be discussed. Prior to the session, assign a reading that addresses key concepts related to the material students will encounter in that session. Create an assessment with multiple-choice questions addressing key concepts from the reading. When students arrive, have them fill out the assessment individually. Form small groups of 4-5 students and have students arrive at consensus regarding the answer most suited to each question, explaining their rationale. Reconvene as a whole class, and ask a representative from each group to indicate the agreed-upon response at the same time. Discuss any variability in responses, responding to questions that arise. These concepts provide the framework for the session. The instructor may give students the decision (within reason) of what percentage of their grade associated with test-taking teams is derived from their individual score versus the group score. Create multiple-choice questions carefully so that the answers require discussion and are not all immediately obvious. Have students choose the *best* answer and be able to justify their response to their teammates. This is a process that encourages discussion resulting in consensus, not simply a matter of the majority vote.[18]	1. Example question that encourages discussion and draws students' attention to key points of the reading in a curriculum instruction course: *Which of the following best describes the meaning of the author's phrase "novice culture" in characterizing aspects of many universities' approaches to improving learning?* a. The university promotes mentoring between "novices" (students) and "experts" (instructors) b. Students establish their own communities of practice, assimilating knowledge from peers c. Reform and improvement efforts are more often mechanical and particularistic, rather than based in systematic research and the wisdom of practice d. A culture that emphasizes the role of the student as a beginner, who requires the guidance of more qualified leaders to learn.

[18] Michaelsen, L.K. (2001). "Getting Started with Team-based Learning". In Team-based Learning: a transformative use of small groups. Retrieved on April 26th 2013, from http://faculty.ucmo.edu/teambasedlearning/docs/Getting%20Started%20with%20TBL.pdf

Method	Purpose This method is effective for…	Description	Example
Short Answer Questions	- Measuring students' analysis, problem-solving and evaluative skills - Evaluating students' ability to apply knowledge	Short answer (or "constructed-response") questions require that students respond briefly to a question or prompt. Responses to these questions are generally between one word and a few sentences long. These questions may be used for formative or summative assessment. "Fill in the blank" or "completion" questions are common. Creating questions and marking responses is fairly fast.	1. In a music theory class: What is the interval between a C# and an F#? 2. In a cinematography course: Name the director and the composer of the film *Schindler's List*.
Student Response System (SRS) / Clickers	- In-progress , non-graded assessment of students' understanding of course content - Gauging students' prior knowledge	Clickers are electronic student response systems that are useful to promote active learning. Because results are analyzed electronically, feedback to students is posted immediately in a histogram format. This standard method can sample a wide range of knowledge quickly and features a variety of formats, including true/false and multiple choice answers. Clickers can be used for single questions or for multiple, related questions (e.g. in response to a case). To encourage student collaboration as part of this exercise, have students consult with peers prior to voting or re-voting on an answer.[19]	In course a professor poses the following question to her class 1. A warship fires two shells simultaneously at enemy ships X and Y. If the shells follow the parabolic trajectories shown, which ship is hit first? A. Ship X. B. Ship Y. C. Both ships are hit at the same time. D. More information is needed After an initial vote on the question, students are asked to discuss their choice with their classmates and justify their selection. After the discussion, they are allowed to re-vote. The instructor provides feedback.[20]

[19] University of Texas, Austin. (n.d.). Teaching large classes: Research and Resources. Retrieved on April 26th 2013, from http://www.utexas.edu/academic/ctl/largeclasses/#RandR

[20] Example is a direct quotation from: University of Guelph. Clickers in the Classroom: Pedagogical Best Practices & Quiz writing Recommendations. Retrieved on April 26th 2013, from http://www.tss.uoguelph.ca/ltci/clickers/clicker-strategies.pdf

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Feedback for Guiding Learning and Informing Instruction

In a course, ongoing feedback on students' work as early and as often as possible has pronounced advantages for both students and professors. For students, it provides affirmation that they are directing their learning appropriately or enables them to adjust their approach accordingly. For professors, it enables them to monitor and track student progress in a course and to revisit difficult topics or resolve confusion in areas that appear to be problematic.

Giving Feedback to Students:

1. **Provide feedback on students' performance as early as possible** in the course—prior to the middle of term if possible and by the middle of the term, at the very latest. Early feedback to students is extremely valuable whether or not an actual grade is assigned to a particular assignment, quiz, test, project or other form of student work. It assures students that their perceptions and efforts are on the right track and enables them to make the appropriate adjustments. If graded, distributing the grade over time and over a range of "artefacts" of student learning further alleviates the anxiety of nearing the end of a course without any indication of their performance to date, or the strength of their grasp on the course material.
2. **Return papers or other work as quickly as possible** preferably at the end of a class, so that students will not be going through comments during class activities. Also, give students an idea of how the class did as a whole, and address common problem areas. Ask students about difficulties they may have had in completing a specific assignment, and discuss suggestions for improving the assignment and students' performance in the future.
3. **Use constructive language in your feedback comments**. Try to balance positive and negative feedback. Avoid sarcastic or punishing comments. Try to direct the student's thinking through guiding questions and helpful suggestions for possible directions for revisions or additions. However, let the student do the revising and be careful not to re-do the assignment or project for them.
4. **Use an assessment rubric** or scoring guide to improve consistency in grading and to save time in determining the quality of students' work. For example, clearly identify the criteria by which different aspects or components of an assignment will be judged, and connect these with specific learning outcomes which have been previously designated as important for that particular course. Examined elements might include statement of purpose, organization and style of project or paper, conclusions reached, evidence provided, and so on—accompanied by examples and/or definitions of performance levels for each component. Rubrics can be created by the instructor or adapted from existing models. You can share these rubrics and assessment criteria with students in advance to provide guidance and ensure understanding.
5. For an entire class, try to **get a general sense of the range of quality in student work** before starting into the actual grading process. For example, papers might be sorted into initial piles on the basis of quick estimates of overall quality. This sorting might help to shape your expectations before you start grading and gives you a sense of how students handled the assignment in general. Share these overall impressions and assessments with students as a group both to provide a context for your feedback on their individual work and to identify strategies to address problem areas.
6. For each individual student, **first read quickly through their work** to try to get an overall initial impression of the general scope and quality, looking especially for potential strengths and possible problem areas. Then, when you review the work in greater depth, your comments can emphasize key points and issues, asking questions and offering suggestions where appropriate and providing focused guidance for improvement. You can concentrate on critical elements of the work, such as

those reflecting the criteria indicated in a previously discussed rubric. Remember to compliment the strengths of the submitted work, and, when possible, to suggest directions for improvement through facilitative questions such as “What conclusions do you want readers to glean from your final summary of the issues?” or “What do you feel is gained by including this section?”

7. **Allow yourself sufficient time** to read and respond to students’ work so as to avoid having to assess and responding to a large number of papers at one sitting. After each break, review the last couple of papers to ensure that fatigue has not adversely affected your judgment.

8. **Supervise and coordinate grading done by graduate teaching assistants**. Grading in any course is ultimately the responsibility of the course instructor. If teaching assistants are charged with grading any of students’ work, all graders must share a similar understanding of what critical elements to look for, what values are placed on different elements, and how the grading process should be carried out. Meetings should be arranged to identify and discuss criteria and rubrics used for grading, and perhaps a number of “sample” papers or exams could be graded to check for consistency among graders. Each grader should review and grade a range of papers, and graders should systematically overlap in grading a sampling of papers or exams in common, again, to ensure consistency in grading.

Obtaining Feedback from Students:

Information about students’ performance in various learning tasks can guide ongoing instructional decisions and help to make informed choices about teaching techniques and materials. In addition, ideas and viewpoints contributed by the students themselves can clarify puzzling observations and reduce the need for instructor speculation. Hence, to provide added insight:

Invite feedback from students at various points during the term about how the course is going from their point of view, including comments about what they like most about the course to date, as well as constructive suggestions for improvement. This feedback helps to generate a complementary and reciprocal feedback “forum,” thereby facilitating an ongoing dialogue between you and students regarding the teaching and learning process throughout the duration of the course.

Information from these measures will enable you to make early or mid-course adjustments or revisions in your teaching, while there is still time for modifications and enhancements to have an impact on student learning and performance. Students in turn will appreciate receiving timely feedback, allowing them to continue their current efforts with assurance or to modify their learning approach and maximize their success in achieving the important learning goals of the course. In large classes, where inviting and providing feedback may seem particularly challenging, use of learning technologies such as “clickers” or classroom survey tools can be especially useful[21]. Whatever techniques are used, providing early feedback to students and inviting their ideas on an ongoing basis has far-reaching implications for monitoring and enhancing the teaching and learning process.

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[21] *myCourses* [https://mycourses.mcgill.ca/] provides two tools for anonymous feedback from students: discussion and survey. Reviewing comments made by students in response to the MERCURY end of term course evaluation questionnaires can also be extremely useful, and the questionnaires can be customized. Examples of useful questions can be found at <http://www.mcgill.ca/tls/teaching/course-evaluations/resources/questionnaire/questions> (last accessed: Apr. 23, 2013)

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Exercise 3: How will I assess learning?

Step 1 (15 minutes)

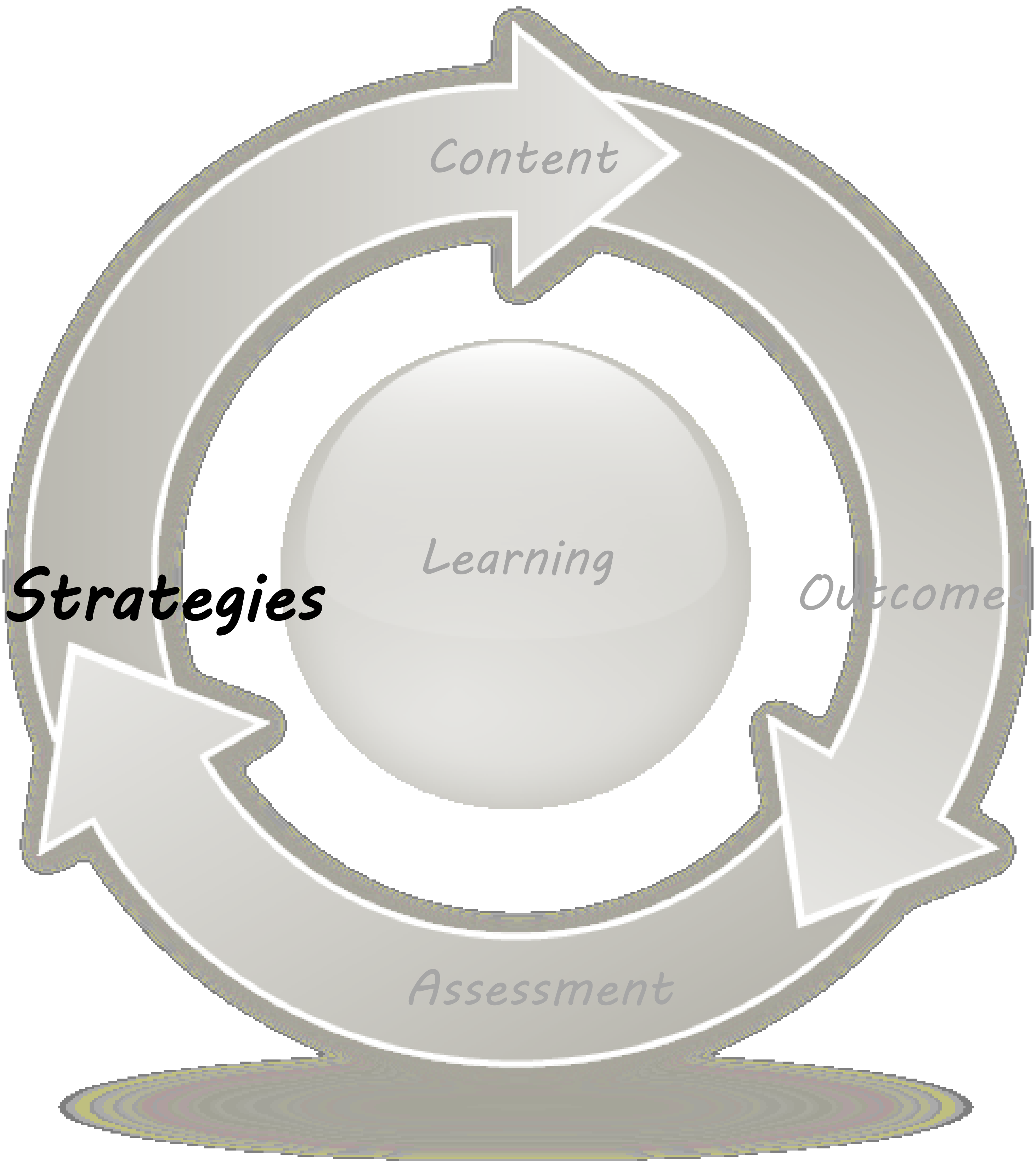
1. Select one of your learning outcomes.
2. Describe what you need to see students do to meet this expectation:
    - design an activity/assignment that would allow you and your students to assess progress toward reaching the outcome (formative assessment)
    - design an activity/assignment that would allow you to judge whether the student has achieved the outcome (summative assessment)
3. If time allows work through additional outcomes

Please keep in mind the following questions as you consider each assessment method:

- Is the assessment method aligned with the outcome?
- Does the assessment method provide feedback to learners on their progress towards achieving the outcome?
- Is it feasible or realistic; i.e. not too much work for you and your students?

Step 2 (15 minutes)

- Share your assessment methods and exchange feedback.


Content
Learning
Strategies
Outcome
Assessment

Engaging students: Strategies from McGill instructors

Across the disciplines, McGill instructors employ a variety of strategies to foster meaningful student engagement with course content. For more examples of McGill instructors' approaches to teaching please consult the following websites: http://www.mcgill.ca/teachingsnapshots/snapshots and http://www.mcgill.ca/law/teaching

Anthony Paré, Integrated Studies in Education

In his graduate-level courses (15 students), Anthony Paré uses small-group discussions to help students develop their understanding of the readings. In groups of three to four, students talk about the course readings. He asks the students to focus on five to six points from the readings that jumped off the page for them: something that puzzled them, something that surprised them, something that bothered them, something they liked. At the end, each group briefly reports to the entire class what really captured their interest.

Kathleen Fallon, Sociology

In her courses "Sociology of Gender" (130 students) and "Gender & Development" (85 students), Kathleen Fallon wants to stimulate interest and thought in the course material and link sociological theories to real life. To achieve this goal, she asks students to post links on WebCT to current newspaper articles that relate to topics being covered in class. When posting a link, students have to state whether they agree or disagree with the article and why.

Ken Ragan, Physics

To create a positive learning environment and reduce anxiety in his course "Introduction to Physics" (600 students), Ken Ragan starts the term with a little questionnaire. He asks the students to respond to four prompts on a sheet of paper: (1) What is your background in physics? (2) Summarize your feelings on taking this course. (3) What does physics mean to you? (4) What can I do to help make the course go better?

In the following class, Professor Ragan presents a quick PowerPoint summary of the answers. He likes to repeat this activity at the end of the term to see if students' attitudes towards physics have changed.

Marcia Waterway, Plant Science

In her undergraduate course "Flowering Plant Systematics" (40 students), Marcia Waterway asked students to define certain concepts that are an important issue in the literature. Different people have different ideas about what certain words mean, so each student had to bring a definition and defend it. This assignment required the students to read, find literature, and understand what they had learned in this course.

Chantal Westgate, Management

To ensure that students in her course “Public Sector Labour Relations” (45 students), follow developments in the labour news, Chantal Westgate asks students to keep a journal where they write down news concerning the labour market. To demonstrate their ability to relate concepts learned in class to specific trends and events, students are further required to provide a 250-300 word analysis of three separate news stories throughout the term.

Marilyn Scott, Parasitology

In her course “Environment & Infection” (35 students), Marilyn Scott has found it very useful to organize a poster session with peer review. For this strategy, the students create posters, which are put up around the class room during one class. Then, all the students go around, read the posters, write a critique of every poster, and do a comparative grading.

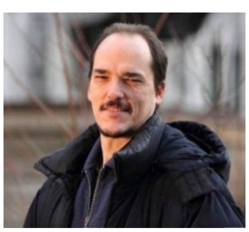
Mark Antaki, Law

In his course “Constitutional Law” (70 students), Mark Antaki uses student-generated questions as part of an assignment. The assignment presents students with the following task: “articulate five questions about courts that emerge from your engagement with the course materials. For each question, write one or two sentences explaining how the question emerges from your engagement with the materials.”

Nicole Biamonte, Music Theory

When teaching “Theory and Analysis 2” (100 students), Nicole Biamonte put up Wikipedia articles on relevant topics and asked students to critique them. This gave students a chance to act as authorities and reinforced the point that not everything written in print or online has validity.

André Costopoulos, Anthropology



In his course “Introduction to Evolutionary Theory” (200 students), André Costopoulos uses games to help students learn challenging concepts. To demonstrate that variation comes prior to natural selection and not vice versa, he has students manage a population of organisms (on paper). In each round, the students first flip coins to determine whether their cells mutate or not. Then Prof. Costopoulos, who plays the role of the environment, changes the conditions. Only those cells with features that thrive in this new environment survive and reproduce.This game helps students understand a difficult concept of evolutionary theory; cells don’t acquire certain traits because the environment is changing. Instead, the cells that happen to have mutations that are favourable given the environment are the ones that reproduce.

Examples of Instructional Strategies[22]

These are just a few of many instructional strategies that encourage student engagement and active learning. For further ideas, from other McGill professors, please check Teaching Snapshots: http://www.mcgill.ca/teachingsnapshots/

Examples of Interactive Strategies[23,24]

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
1. Background Knowledge Probes (*) see *Test-taking teams*	• Instructor determines effective starting points / appropriate levels of instruction for a given subject or class. • Students focus their attention on important material	A background knowledge probe (BKP) asks for basic, simple responses (short answers, circling / showing of hands, multiple choice questions) from students who are about to begin a session or study a new concept.	1. For carrying out BKPs in large classes, clickers (Student Response Systems) can be a very quick and thorough method of tabulating student responses to multiple choice questions. 2. Students may brainstorm together and work to arrive at a common answer prior to reporting out on their response.	1. During an introductory music theory course, ask how a minor third is formed. 2. In a philosophy course, ask students to summarize the historical context for Plato's *The Republic*.

[23] Adapted from *Scenes from a classroom: Making active learning work* (http://www1.umn.edu/ohr/teachlearn/tutorials/active/index.html) and *Active learning with PowerPoint* (http://www1.umn.edu/ohr/teachlearn/tutorials/powerpoint/) [last accessed: April 26th, 2013].

[24] Some strategies and examples adapted or taken directly from Barkley, E.F., Cross, K.P., and Major, C.H. (2005). *Collaborative Learning Techniques*. San Francisco: John Wiley and Sons.

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
2. Brainstorming	• Students generate a large number of ideas for potential solutions to a problem • Students develop team learning skills	1. State the issue and generate ideas regarding the issue, having agreed upon a time limit. 2. Categorize, combine, condense and refine ideas 3. Assess potential solutions	1. Ask students to not only brainstorm ideas, but also verbalize the relationships between the ideas. 2. May be complemented by a mind-mapping activity. 3. Brainstorming can take many different forms. Some examples presented elsewhere in this document include: • Focused listing • Mind mapping • Roundtable • Think-pair-share • Closing summary • Corner exercise	Ask students to come up with potential courses of action for a company facing a particular engineering challenge.
3. Buzz Groups	• Students develop teamwork and cooperative learning skills	1. The instructor divides the class into subgroups to discuss an assigned topic or to solve a problem. 2. Participants can briefly present their findings to the whole group so that the instructor can respond to comments and stimulate discussion.	1. Enforce a time frame to avoid side conversations and keep students focused. 2. When students report out, challenge groups to contribute only ideas that haven't yet been mentioned.	1. In a communications course for engineers, students are presented with a technical manual and asked to re-write different sections in small teams to make them more accessible to a non-expert audience.

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
4. **Cases**	• Students apply theory to practice by discussing realistic, relevant scenarios. • Students encounter real-world, authentic contexts that expose them to viewpoints from multiple sources and help them to see why people may want different outcomes.	Provide scenarios students may encounter when they would need to use the information learned during the course. It is helpful to provide time for questions after the case scenario is introduced.	1. This strategy can be combined with a think-pair-share: students first generate a couple of approaches to the case individually and then pair up. In pairs, students share their proposed scenarios, and then chose one to pursue further and elaborate upon.	The instructor presents students with numerous building proposals. Students must evaluate which proposals will be approved and which will be declined, and justify their responses.
5. **Closing Summary** (list key concepts or ideas)	• Instructor ascertains whether students were able to identify / grasp the key topics. • Students reflect on their learning.	Have students write a closing or “exit summary” individually or in pairs, listing or summarizing the main ideas about the topic presented during the session. Students can compare and contrast their summaries in pairs to build upon one another’s understanding of the material.	1. Make certain to set aside a couple of minutes at the end of class for this strategy. Teachers may selectively collect the lists and summarize the main points, addressing misconceptions at the beginning of the next class. 2. Ask students to summarize the previous class session at the beginning of the next one, to ensure continuity between class periods.	1. What were the three key points or “take-aways” of today’s class? 2. What did you find most interesting? What did you find least interesting? What did you want to learn more about? 3. If you were to make two exam questions that consider the main points from today’s material, what would they be? How would you answer those two questions?

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
6. Corner Exercise / "write around the room"	• Students build upon one another's knowledge • Instructor becomes aware of which concepts are clearly understood, and which concepts were *not* incorporated into students' knowledge base.	1. Form groups 2. Each group moves to a corner and brainstorms a list in response to a question posed to the entire class 3. Move to the next corner—expand on the previous group's examples 4. Review the contents of each list as a large group	1. Students can put a check mark next to previously listed responses that are consistent with their lists. 2. Set and keep a time limit for this activity, to ensure that students have sufficient time at each of the corners. 3. Once students have completed this activity, they might organize the results using concept mapping, to further crystallize their understanding of the concepts' relation to one another.	1. In an English literature course: What are recurring features of Lord Byron's poetry? How do these stylistic elements hint at his intended audience? What are the key traits of the Byronic hero?
7. Critical Debate	• Students work to articulate their thoughts and solidify their understanding of numerous aspects of the task / situation at hand by debating for one side or the other.	1. Students use two different methods that could be applied to solve a problem or arrive at a solution in response to the concepts introduced. 2. Alternately, the class can be divided to debate the merits of one method or solution over the other. The presenter leads a group discussion afterwards, asking students to argue for the point of view indicated, or compare experiences.	1. May be combined with the "Fishbowl" strategy above. 2. After arguing for one side or the other, students argue for the alternate point of view, attempting to elicit new rationales. 3. By combining this with the "Fishbowl" strategy, student onlookers can provide feedback on the debate, and discuss which arguments were most compelling and convincing.	1. In a labor relations class, students debate proposed cuts to an employee benefits package. Half of the students represent the business, which has been charged with reducing its budget; the other half represent the employee union, which objects to some of the proposed modifications.

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
8. Dialogue Journal / clinical log book	• Students develop their communication skills and reflect upon the application of prior knowledge or personal experience to course material or clinical situations. • Students increase their collaboration and a sense of classroom community as students respond to one another's journals • Students clarify and extend their explanations and rationales in response to classmates' written comments.	1. Students draw a line down their journal page 1/3 of the way in from the right margin. The responder will write to the right of the line. 2. The writer reflects upon an assignment, clinical experience, lecture, class task / activity or discussion, including his or her comments and questions. 3. The respondent reads the journal entry and provides comments, clarifying questions, answers to the writer's questions, etc. 4. The instructor reads the journal entries and responses.	1. Clarify parameters and expectations for journal entries. 2. As students may take variable amounts of time for journaling, the writing and response can take place outside of class time, as an opportunity for follow-up and reflection upon in-class experiences. 3. Have students submit their journals regularly. 4. Keep a community dialogue journal for all students to record questions or ask for clarification; students respond to one another's questions within the journal. Questions may also be addressed in-class. 5. Have students write their journal entries in letter format.	1. In a Shakespeare course, have students compare and contrast the written play and movie versions. Ask them to identify elements of the play that were either emphasized or left out in the screenplay, and the impact they think this had upon the representation and the audience's response. 2. In a course on clinical practice, students reflect upon their stage or other experiences with patient care – decisions made are explained with a rationale, and outstanding questions are posed for feedback.

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
9. Fishbowl (outside-inside circles, Socratic seminar)	• Students participate in structured, in-depth discussion • Students model, observe and critique group processes through the discussion format	1. Students form a small circle (group of 4-6 students). Remaining students form a larger circle around the 4-6 students. 2. Present guidelines for the activity: students in the inner circle speak, while those in the outside circle observe (considering both the discussion and group process). Students in the outside circle will have an opportunity to speak to the issues that arose during the discussion in the follow-up time. 3. Present the discussion prompt. Inner circle students debate. 4. Students report out in a whole-class discussion, encompassing key issues and the group process.	1. Do not try this the first day of class: first develop a level of trust, a non-judgmental environment and sense of collaboration. 2. Have students facilitate the discussion; step in only if necessary. 3. Conduct multiple, smaller fishbowls concurrently. 4. Allow students to trade out between the outer and inner circles every few minutes, to expose different points of view and to see different group dynamics.	1. In a biology class, students respond to the question "Why are we worried about changes in the ozone layer?"[25] 2. In a class on higher education administration, students debate whether higher education is (or is not) an industry.[26]

[25] Barkley, E.F., Cross, K.P., and Major, C.H. (2005), p. 146
[26] Barkley, E.F., Cross, K.P., and Major, C.H. (2005), p. 147

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
10. Focused Listing	• Instructor identifies students' prior knowledge or attitudes • Students recall what they have learned about a topic	Students recall what they know about a subject by creating a list of terms or ideas related to it. 1. To begin, the instructor asks students to take out a sheet of paper and generate a list based on a given or chosen topic. 2. Instructors ask students to share their lists. *Note: Can be used before or after instruction. Focused listing need not take more than a few minutes.*	1. Impose a time limit and inform students. 2. Students share their lists in small groups. 3. Students make a focused list prior to the discussion and then add to the list (correcting any prior misconceptions) at the end of the class period. 4. May be used in conjunction with the "Roundtable" strategy. 5. Students share their lists in small groups and identify the two to three most important points, which they then share with the class.	1. In an educational psychology course, students provide examples of defining characteristics of Piaget's stages of cognitive development. 2. In a political science course, students identify the pros and cons of a government's proposed course of action currently in the news.
11. Jigsaw	• Students develop teamwork and cooperative learning skills • Students integrate knowledge and understanding from various sources and experts. • Students engage in their own learning • Students learn a lot of material in a limited amount of time • Students are individually accountable for their learning	Groups are formed to discuss different portions of a larger scenario or problem; group members then report out. 1. Divide a topic into related portions. 2. Divide students into "expert groups"; each group will study and address a portion of the topic. 3. After researching / investigating their specific focus, the expert groups are split up so that the resulting groups have one member from each of the expert groups. 4. Upon gathering the new groups together, each topic expert presents, integrating the knowledge of his or her specific topic into the new group's collective understanding.	1. Encourage students to take notes of key points generated during step 3, which will help them to prepare for step 4. 2. Review previously discussed concepts. 3. A chosen group from step 3 reports out to the entire class; facilitate a brief discussion in response to their key points.	1. In a plant science course, students review the characteristics of various types of trees (conifer, deciduous, etc.) and corresponding climate zones in expert groups and then report out to their new groups.

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
12. Mind mapping	• Students demonstrate their understanding of a topic (prior to / following instruction)	Ask students to identify key concepts about a topic to create a visual representation of the relationship between those ideas. Students can use basic elements such as boxes, arrows (uni- or multi-directional), simple hierarchical relationships or "webs" coming from one central point, to identify concepts and relationships.	1. Provide examples of various formats of mind maps to give students options for various graphical frameworks they might use to express the relationships between concepts. 2. Students compare and contrast their mind maps in pairs, working towards a single map that incorporates all agreed-upon elements.	1. In a course on international relations, students create a visual representation of the purposes, scope, impact and reach of the United Nations. 2. In a pharmacology course, students create a critical distinctions chart to compare and demonstrate the differences between similar drugs. 3. In a biology class, students draw the phases of mitosis, including a diagram of the cell at each phase.
13. Muddiest Point	• Students reflect upon which aspects of the course material are the least clear to them.	Ask students to write down what seemed most confusing to them. Feedback from students can be used to create new ways to discuss those points that multiple students found to be unclear.	1. Encourage students to be very specific in identifying the source of confusion. 2. The instructor can begin the next class by reviewing selected "muddiest points". 3. Students attempt to answer one another's "muddiest point" questions. 4. Students indicate what information they would need to better grasp the course material discussed.	1. What was the "muddiest point" of the material discussed today? 2. Write one thing that wasn't clear to you from today's course material. Why do you think this was confusing?

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
14. One Minute Paper/Free Write	• Students briefly explore ideas before discussion • Students bring closure to a session by recording the ideas in their minds at that moment.	Students are asked to write for 1-5 minutes on a topic or in response to a question that you have developed for the class period.	1. You might emphasize content over form, so that students focus on expressing their ideas given the time limitation. 2. This can be used as an "exit survey" – a means for students to summarize what they understood to be the key points of the class period. 3. Students can approach a new topic by writing down what they know and want to know at the beginning of the class, and then follow this with a reflection of what they learned at the end of the class time.	1. In a survey course on art history, students describe the characteristics of Impressionism. 2. In a Canadian studies course: "What are some of the ways in which climate change is affecting the Arctic and its inhabitants?" 3. In a course on scientific principles students are asked to "Identify important scientific discoveries of the 20th Century in the field of medicine".[27]
15. Pre-and Post-Quizzes	• Students assess their comprehension and evaluate their learning over the course of the class period. • Instructor gathers information about students' prior knowledge and assesses learning over the class period.	1. Create a 1-page quiz that covers the primary focuses of your session 2. Have students take the quiz at the beginning of the session, and then set it aside. 3. When the students take the same quiz at the end of the lesson, they will see what they have learned instantly. 4. Having the students pass in their quizzes provides timely feedback to the instructor on their learning over the course of the session.	1. Ensure that sufficient time is allotted to convey the correct answers at the end of the session, and to answer any questions that arise as a result. 2. Student responses to the pre-quiz can be incorporated into review sessions later in the class. 3. Students might follow the post-quiz with a one-minute paper summarizing what they learned.	1. In an introductory biology course, students are asked to put the steps for meiosis in order and label the structures both prior to and following the lecture.

[27] Barkley, E.F., Cross, K.P., and Major, C.H. (2005), p. 242

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
16. Presentations	• Students and instructor are able to gauge the following: preparation; understanding; knowledge; capacity to structure information; and oral communication skills. • Students and instructor can provide feedback. • Students respond to questions and manage discussion.	Students express their knowledge on an assigned topic to classmates and instructor. May range from informal to formal. Presentation length, size of presenting group, structure of presentation, criteria and technology used within the presentation may all vary.	1. Provide students with a rubric and discuss expectations for presentations. 2. Discuss providing constructive feedback to peers. 3. Encourage student feedback and involvement in the establishment of rubric criteria for evaluating presentations. 4. To help students become familiar with presentations, they might begin by presenting to small groups of their peers, rather than to the entire class at once. The listening members of the small group can then summarize and report out to the larger class on the 3-5 key ideas of the presentation.	*Presentations can be given on virtually any topic.*

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
17. Problems	• Students develop communication, problem-solving, and self-directed learning skills.	Students individually or collaboratively solve problems, apply what they have learned in the course and reflect on their experiences. Teachers take on the role as "facilitators" of learning.	1. For collaborative problem solving, groups should be chosen carefully, to facilitate students' interactions and promote a productive group dynamic. 2. Have students create their own problem-based learning prompts, vet them then re-distribute amongst their classmates. 3. Students reflect upon how different conditions might affect their response, or approach the same problem from a different point of view. (For instance, in the example given, they might propose solutions from the perspective of an organic farmer, a pesticides company, and a community-supported agriculture organization.)	1. In a plant science course: Numerous farmers in the Eastern Townships report that their tomato plants are stunted and withered. What would you propose as the cause of this unhealthy appearance? What would you suggest that the farmers do to approach this problem? Using the resources, find background context, discuss in your team, and justify your response.

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
18. Questions	• Students are actively involved in class as they apply concepts and content learned. • Instructor determines student comprehension of content	1. The instructor provides engaging, challenging questions or asks for guidance during class time. 2. Students then provide answers either working individually, with a partner, or in a small group. 3. Questions should relate to learning outcomes and be thoughtful and reflective (Simple, yes/no, factual questions are not enough).	Students need sufficient time to respond. Think about instruction in terms of the questions you hope are being answered – "If this session is the answer, what is the question?" and phrase your question prompts accordingly. For more complex queries, instructors might consider providing questions in written form so students can continue to refer back to them. Instructors might ask the same core question(s) on the first and last day of the course or unit as a method of formative and summative assessment. Students formulate their own questions based upon what they see as the key points of the topic at hand. These questions are then opened up to the class for discussion, or discussed in small groups.	1. In a course on small business management and practice, the instructor asks students how they would attract new clients, given a limited budget or other constraints. Ask students to make reference to concepts discussed in class or in the readings in their responses. 2. In a Medicine course, students are asked to respond to the following scenario: "A 6 week old child is admitted to the ER crying a lot with respiratory pauses. X-rays point to 3 posterior rib fractures. What would you do next?" *See questions asked in examples throughout this column.*

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
19. Roundtable	• Students summarize key concepts • Students participate equally • Students build on their peers' knowledge and respond to one another's conceptions	1. The instructor creates a prompt, which is written down in a highly visible location. Students are informed of the time limit that has been set for this activity. 2. In groups of four, students pass around a sheet of paper clockwise responding to the prompt in short phrases or sentences. After each student writes his or her response, it is read aloud so the others can reflect upon it while the paper moves around the group. 3. Ensure that all members have an opportunity to write their ideas down on the paper.	1. Use for review or for brainstorming lists – fairly simple, straightforward prompts that keep the paper moving around the group. 2. Encourage student to respond to the comments of those who have already written on the sheet. 3. Follow-up with group or whole-class discussion using the round-table papers as a base or departure point. 4. Use in conjunction with the "muddiest point" strategy: students write down their muddiest point, check those muddiest points that have already been written by others and expand as appropriate. The instructor may follow up by facilitating a discussion of the muddiest points.	1. In a course on scientific principles: "Identify important scientific discoveries of the 20th Century in the field of medicine".[28]

[28] Barkley, E.F., Cross, K.P., and Major, C.H. (2005), p. 242

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
20. Ten-Two Strategy	• Students process information presented. • Instructor and students fill in any gaps or misunderstandings. • Students clarify information for one another; build on peers' knowledge	Presenter shares information for ten minutes and then stops for two minutes to encourage listeners to pair up with a partner and share their ideas.	1. Encourage students to pair up with different classmates each time this activity is carried out. 2. At the end of the information-sharing time, pairs can pair up (making groups of 4 students) to summarize the 3-5 key points or "take-aways" from the session. 3. This activity may be used when students are watching classmates' presentations. This can be effective in maintaining audience focus and provides helpful feedback to the presenter in determining whether he or she successfully communicated the points intended.	1. In an U.S. History of the 20th Century course, the instructor asks students to summarize the economic impact of the Great Depression on the North American labour market in the 1930s and 1940s. 2. In a Canadian studies course: "What are some of the ways in which climate change is affecting the Arctic and its inhabitants?"

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
21. Test-taking teams: readiness Assurance	• Students become actively engaged with the course content through collaboration with peers. • Students are responsible and accountable for their own learning and for contributing to a team.	1. Prior to the session, assign a reading that addresses key concepts related to the material students will encounter in *that* session. 2. Create an assessment with multiple-choice questions addressing key concepts from the reading. 3. When students arrive, have them fill out the assessment individually. 4. Form small groups of students and have students arrive at consensus regarding the answer most suited to each question, explaining their rationale. 5. Reconvene as a whole class, and ask a representative from each group to indicate the agreed-upon response at the same time. 6. Discuss any variability in responses, responding to questions that arise. Explain that these concepts will provide the framework for the day's session.	1. Create multiple-choice questions carefully so that the answers require discussion and are not all immediately obvious. Have students choose the *best* answer and be able to justify their response 2. Encourage students to be able to rationalize their responses to their teammates. This is a process that encourages discussion resulting in consensus, not simply a matter of the majority vote. 3. The instructor may give students the decision (within reason) of what percentage of their grade associated with test-taking teams is derived from their individual score versus the group score.	1. Example question that encourages discussion and draws students' attention to key points of the reading in a curriculum instruction course: *Which of the following best describes the meaning of the author's phrase "novice culture" in characterizing aspects of many universities' approaches to improving learning?* a. The university promotes mentoring between "novices" (students) and "experts" (instructors) b. Students establish their own communities of practice, assimilating knowledge from peers c. Reform and improvement efforts are more often mechanical and particularistic, rather than based in systematic research and the wisdom of practice d. A culture that emphasizes the role of the student as a beginner, who requires the guidance of more qualified leaders to learn.

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
22. Think-Pair-Share	• Students organize prior knowledge. • Students, summarize, apply, or integrate new information. • Students build individual accountability and contribution: each student reports to a partner, and partners summarize in a short report to the class.	1) Individuals reflect on (and perhaps jot down notes) in response to a question. 2) Students pair up with someone sitting near them and share responses / thoughts verbally, or they may choose to work together to create a synthesis of ideas or come to a consensus. 3) The discussion leader randomly chooses a few pairs to give summaries of ideas.	1. Intentionally choose different pairs to give summaries of their ideas each time this activity is carried out. 2. After the pairs have discussed their responses, have two pairs discuss together, in lieu of randomly choosing pairs to report out to the entire class. 3. Use visual stimuli (e.g. photographs) as a prompt for discussion	1. In a medical course, students offer potential diagnoses and treatments based on photographs of conditions and case histories. 2. In a classroom management course, ask students how they would respond to an off-task student's interruptive behavior. Have students come up with a solution individually, then pair with a classmate, justify it and come to a consensus on an appropriate approach to this scenario.
23. Simulations	• Students apply their knowledge of structures, concepts, and best practices to virtual or other situations that simulate real-life occurrences. • Instructors and students reflect upon the students' response	1. A person, system or computer program demonstrates an action, symptom or scenario to which students are expected to respond. 2. Given the information presented, students take the appropriate action or give a detailed verbal explanation of what they would do to solve the problem or address the situation. 3. Students and instructor debrief, discussing the simulation and students' responses.	1. As a variation, students may take turns simulating (through role play) the appropriate action, symptom or scenario, to which classmates then respond.	1. Students in a health and safety course practice using a defibrillator with a lifelike mannequin. 2. Students in an investment course buy and sell stocks in a trading room simulation, evaluating the success of their portfolio and explaining their rationale for various decisions made.

Strategy	Purpose	Description of Strategy	Implementation Suggestions and Variations	Examples
24. 3-step Interviews	• Instructor determines students' comprehension of course content • Students improve communication, paraphrasing and small-group presentation skills • Students learn from and about their classmates	Form groups of 4 students; each group is further divided into two pairs (A-B and C-D). 1. Student A interviews student B, while student C interviews student D. The student asking questions listens and asks for further details. 2. Student B interviews student A, while student D interviews student C. 3. Students A and B summarize one another's responses to the other two students, then vice versa.	1. Use this strategy to help students explore opinions or experiences related to course content, thereby activating their prior knowledge. 2. Create interview questions that will not all generate the same responses, but rather will result in a diverse offering of comments and interpretations. 3. Students develop interview questions around a central theme 4. Students report results of the interview in a written format that is related to the course (e.g. business case, essay)	1. In a music appreciation course: "What musician recording today do you think people will still be listening to in fifty years, and why?"[29]

References / Resources

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[29] Barkley, E.F., Cross, K.P., and Major, C.H. (2005), p. 122

Exercise 4: What instructional strategies will I use to facilitate learning?

Step 1 (10 minutes)

- Choose one of your learning outcomes.
- Select an instructional strategy that will help students achieve that outcome (please see box below "Selecting Instructional Strategies")
- Try to work through two or more outcomes if time allows.

Step 2 (10 minutes)

- Share your instructional strategies and exchange feedback with the person next to you.

Selecting Instructional Strategies

Consider the following factors when selecting instructional strategies:

- Learning outcomes
  - Strategies must be aligned with learning outcomes, i.e. they must support the type and level of learning specified in the outcome.
- Learners
  - Consider their experience, learning preferences, etc.
- Context
  - The context defines what is possible and/or expected. Consider resources, the learning environment, the culture surrounding learning, etc.
- Purpose
  - Consider strategies for engaging, informing, practice, and feedback.
  - Consider strategies that promote active and collaborative learning.
  - Consider your choices of instructional strategies, and decide which are best done (or need to be done) in class, best done out-of-class.

Putting It All Together

Aligning Design Components: The Design Table

Outcomes	Assessment	Strategies	Notes

Example of a Design Table[30]

Examples of whole course design based on inquiry[31]

Outcome	Assessment	Teaching and Learning Strategies
Describes the important elements of [discipline] research	Quizzes	Mini lectures Practice sessions about research tools. Doing a research project – full inquiry cycle Learning about others' projects Reflecting on the project and their learning
Describes the characteristics of an effective research design		
Uses appropriate research tools	Research project proposal (feedback) Research project	
Selects from a range of techniques used in solving [discipline] problems		
Designs and executes a research project		
Critically evaluates research	Literature review or comparative critique	Tutorial – practice in critiquing papers
Able to work in a team to solve problems	Self and peer assessment of contribution to group	Group project work
Communicates research via written, visual and oral means	Research Report, poster and/or oral presentation	Opportunities to present work, workshops on communicating research

[30] Based on Rachel Spronken-Smith, from the Higher Education Development Centre, University of Otago, New Zealand, *The use of inquiry-based learning to strengthen teaching-research links*. McGill University, January, 2009.

School of Physical and Occupational Therapy, McGill University
Course alignment with Evaluation methods & Instructional activities[32]

OCC1 550 – Enabling Human Occupation Professor Cynthia Perlman		
Outcomes	**Asessment**	**Strategies**
1. Define Occupational Therapy, occupation, occupational performance/identity/ develop/engagement, and occupational science.	• Reflective journal • Instructor & peer feedback • Final exam: (short answer and short essay)	• Role play • Reading questions
2. Explain the philosophies, definitions, frameworks and/or models of human occupation in relation to the concepts of health, function and justice.	• Reflective Journal • Instructor & peer feedback • Final exam	• Activity labs (2 hrs) • Guest speaker and question period • Reading questions • In-class collage project
3. Experience a variety of purposeful activities and their impact on occupational needs.	• Web tutorial • Case-based Group project on activity analysis • Instructor & peer feedback	• Activity labs • Web tutorial
4. Discriminate between the domains of the Traditional Analysis (TA) framework in order to apply a purposeful activity to meet occupational needs.	• Final exam • Web tutorial • Case-based Group project on activity analysis • Instructor & peer feedback	• Activity labs using case-based contexts • Web tutorial
5. Relate the domains and sub-domains of two models of practice 1) Canadian Model of Occupational Performance (CMOP-E) and 2) Model of Human Occupation (MOHO).	• Web tutorial • Group project on activity analysis • Reflective journal • Final exam • Case-based Group project on activity analysis-instructor & peer feedback • Reflective journal	• Activity labs using case-based contexts • Web tutorial
6. Apply "activity analysis" to the TA, CMOP-E, and MOHO, in terms of the individual and the environment.	• Web tutorial • Group project on activity analysis • Final exam • Group project on activity analysis-instructor & peer feedback • Reflective journal	• Activity labs using case-based contexts • Web tutorial
7. Adapt or modify a purposeful activity (termed grading), in relation to a new content and context, to facilitate health and well-being.	• Web tutorial • Group project on activity analysis • Web tutorial • Case-based Group project on activity analysis- instructor & peer feedback • Reflective journal • Final exam	• Activity labs using case-based contexts • Web tutorial

Revised by C. Perlman, May 20, 2010

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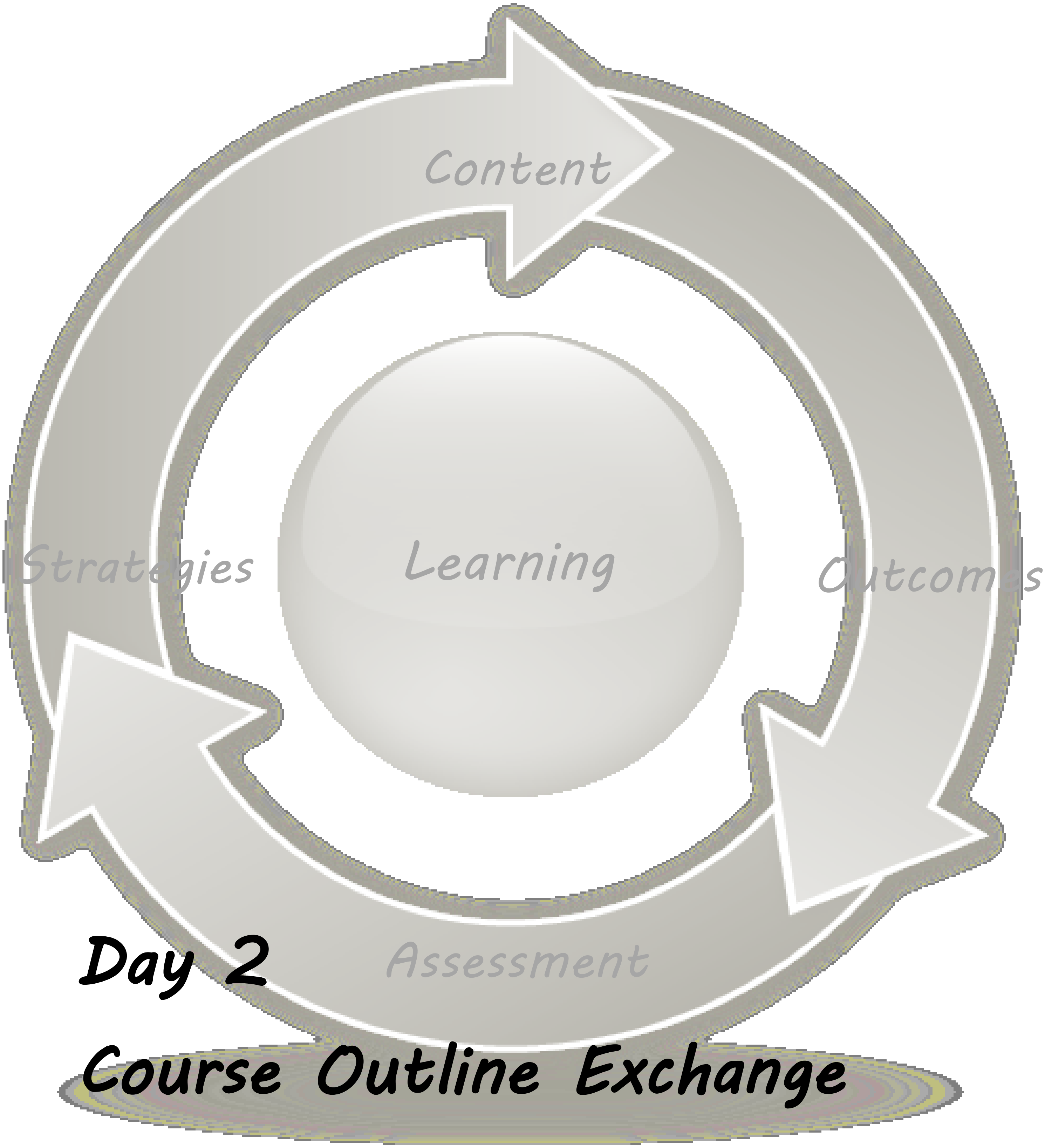

Day 2
Course Outline Exchange

Course Outline Exchange[33]

A well-designed Course Outline provides a rationale for the course, clarifies expectations, organizes information, sets the tone for class interactions, and guides student learning. It clearly communicates to students the course goals, content, strategies and methods of assessment.

For instructors, creating or redesigning a Course Outline provides an opportunity to examine how the content, learning outcomes, strategies, and assessments work together to support student learning and how their outline communicates these components to students. Sharing feedback with peers during this process can be very helpful to generate ideas about the different course components and how they are communicated to students.

The *Course Outline Exchange* provides a setting where ICDT participants can give and receive feedback on their Course Outlines.

A) Preparation for day 2

- **Bring a current syllabi or prepare a draft of your course outline** based on the McGill Course Outline Brief guide:

http://www.mcgill.ca/tls/teaching/course-design/outline

- **Self-assessment**: Look over the "Guiding Questions for the Course Outline Review" (next page) and ask yourself: what ideas do I get from the questions? What is still unclear?
- Bring an electronic copy of your Course Outline to the workshop.

B) Day 2: Course Outline Exchange

Break into groups:

1. **Exchange Course Outlines:** In your group, exchange Course Outlines and, individually, spend about 10-15 minutes reading and reviewing Course Outlines. As you read another person's Course Outline, note questions and possible suggestions.
   - *Overall, consider how well the content, teaching strategies, and assessment methods seem to support students' learning.*
2. **Present the Course:** For *2-3 minutes*, talk about your course:
   - Have you taught it before? How comfortable are you with the material being taught?
   - Who are your students? How large is the class?
   - What are the challenges of the course (for the instructor and students)? How do these challenges shape the structure of the course? What are your concerns?

[33] Adapted from: The Syllabus Workshop. Center for Teaching & Learning, Connecticut College. Michael Reder (reder@conncoll.edu), August 2006.

3. **Get Feedback on the course and the Course Outline** with readers taking turns in asking questions and offering feedback. Count on 15-20 minutes of discussion for each Course Outline.
4. **Repeat steps 2 and 3 with each participant** until all participants have received feedback.

Guiding Questions for Course Outline Exchange

Overall Question:

- How well do the content, teaching strategies, and assessment methods seem to support students' learning?

Specific Questions:

- Does the Course Outline provide a clear explanation of the overall purpose of this course? (e.g., why does this course exist? How does it fit into the larger curriculum? For whom it is designed?)
- Are the learning outcomes (i.e., the knowledge, skills, and values that students will learn as a result of participating in the course) clearly articulated? Are they appropriate to the students' level?
- Does the Course Outline clearly communicate topics to be addressed in the course (e.g., includes a concept map, sequence of topics, rationale for the sequence when appropriate)
- How do the teaching strategies (e.g., lecturing, discussions, guest lecturers, group activities) help students reach the learning outcomes and/or become more engaged? How do the strategies prepare students for the evaluation?
- Are there multiple opportunities, both un-graded and graded, for students to receive timely feedback on their learning?
- Does the Course Outline clearly communicate how the students' work will be assessed? How grades will be assigned? How do the selected methods for evaluating student learning relate to the learning outcomes of the course? Are there a range of methods used to support different kinds of learners?
- Are course policies and expectations clearly defined?
- Is the workload reasonable, well timed, and sustainable for the students and the instructor?

General Resources

Books

Bain, K. (2004). *What the best college teachers do*. Cambridge, MA: Harvard University Educational Publishing, Inc.

Barkley, E. (2010). *Student engagement techniques: A handbook for college faculty*. San Francisco: Jossey-Bass.

Blumberg, P. (2009). *Developing learner-centered teaching: A practical guide for faculty*. San Francisco: Jossey-Bass.

Brookfield, S.D. (1995) *Becoming a critically reflective teacher*. San Francisco: John & Sons Inc.

Christensen Hughes, J., Mighty, J. (2010). *Taking stock: Research on teaching and learning in higher education*. Montréal: McGill-Queen's University Press.

Fink, L. D. (2003). *Creating significant learning experiences: An integrated approach to designing college courses*. San Francisco: Jossey-Bass.

Grunert O'Brien, J., Millis, B.J., and Cohen, M.W. (2010). *The course syllabus: A learning-centered approach. (*2nd ed.) San Francisco: Jossey-Bass.

Lee, V.S. (Ed.) (2004) *Teaching and learning through inquiry: A guidebook for institutions and instructors.* Sterling: Stylus.

Light, R.J. (2001) *Making the most of college: Students speak their minds*. Harvard: Harvard University Press.

Ramsden, P. (2003) *Learning to teach in higher education*. 2nd ed. New York: Routledge.

Weimer, M. (2002). *Learner-centered teaching: Five key changes to practice*. San Francisco: Jossey-Bass.

Examples of Journals about Teaching and Learning in Higher Education

Academe:
http://www.aaup.org/AAUP/pubsres/academe/

Active Learning in Higher Education:
http://alh.sagepub.com/

Higher Education:
http://www.springerlink.com/content/102901/

Studies in Higher Education:
http://www.tandf.co.uk/journals/CARFAX/03075079.html

Journal of Higher Education:
http://www.ohiostatepress.org/Journals/JHE/jhemain.htm

Innovative Higher Education:
http://www.uga.edu/ihe/ihe.html

Teaching in Higher Education:
http://www.tandf.co.uk/journals/titles/13562517.asp

Examples of Engineering Journals for Higher Education

Chemical Engineering Education:
http://cee.che.ufl.edu/

European Journal of Engineering Education:
http://www.tandf.co.uk/journals/journal.asp?issn=0304-3797&subcategory=ET150000

International Journal of Engineering Education:
http://www.ijee.dit.ie/

Journal of Engineering Education:
http://www.asee.org/papers-and-publications/publications

Journal of Sustainability in Higher Education

http://www.emeraldinsight.com/journals.htm?issn=1467-6370