


## Agenda

- Reminders
- **Course Summary**
- **Lectures Summary & Review Questions**
- **Central Topic Covered, & Skills Learnt**
- **Advices:** Considerations for Effective Learning





## Reminders

- **Lab 9** (Project Work): This week
- **Project Plan** (Week 4,6,8,10): Weekly review & update
- **Quiz 4** (Lecture 14 & 16): 16 Mar.
- **Deliverable H** (Prototype 3 & Customer Feedback): 22 Mar.
- **Deliverable I** (Design Day Materials + de 3-min. Video ): 24 Mar.
- **Deliverable I** (Design Day): 26 Mar.
- **Deliverable J** (Submission of Final Presentation): 29 Mar.
- Final Peer Feedback & Team Dynamics: 05 Apr.
- **Deliverable K** (User Manual): 05 Apr.
- **Final Exam**: 21 Apr., morning from 9:30 to 12:30
- What is your summary of **Lecture 16**?
  - Qualities of an effective presenter
  - Attributes of a good presentation display
  - Buying drivers
  - Percentage of nonverbal and verbal communication in a presentation

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## Course Overview

| # | Course Chapter |
|---|---|
| 1 | Introduction |
| 2 | Design Case Study: Rainwater Harvesting System |
| 3 | Design Thinking |
| 4 | Needs Identification & Problem Definition |
| 5 | Client Meeting 1 & Discussion |
| 6 | Design Criteria |
| 7 | Teamwork & Conflict Management |
| 8 | Concepts Generation |
| 9 | Time & Project Management |
| 10 | Design Analysis |
| 11 | Feedback & Prototyping |

| # | Course Chapter |
|---|---|
| 12 | User Experience Design |
| 13 | Modeling |
| 14 | Failures & Iterative Testing |
| 15 | Client Meeting 3 & Presentation |
| 16 | Effective Communication |
| 17 | **Course Summary & Lessons Learnt** |
| 18 | Case Study as Course Review: |
| 19 | Final Exam Preparation |
| 20 | Project Work |
| 21 | Project Work |
| 22 | Final Student Presentation 1 |
| 23 | Final Student Presentation 2 |



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## 1. Introduction to Engineering Design

- Engineering Design Process
  - Often an iterative decision making process using fundamental principles of sciences, mathematics and engineering sciences to convert resources optimally to meet a stated objective.
- Elements to Consider for a Successful Project Team
  - Diversity in personalities, culture, education and expertise
  - Active ongoing communication
  - Organization et punctuality
  - Respect, support and open mind
  - Enthusiasm
  - Shared leadership & Energies in a team



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## Review Questions: Introduction

1. What is **engineering design**? What are the differences between the problems in engineering science and those in engineering design?
2. How important is the use of an **engineering design process**?
3. What are the **five basic elements** to consider when producing a **project plan**?
4. You are the project manager and lead designer of a young smart cushion design company and are responsible for recruiting a designer to join your design team. List at least **five attributes** to consider when recruiting a new member to form an **effective project team**. What would you do to ensure good use of the total energy of your GNG1103 project team and productive leadership of your team?
5. You are in charge of recruiting five designers for the design of smart curtains. What **tool** could you use to know the **personality traits** of your designers?
6. How do you learn and what can you do to **learn effectively and efficiently**?

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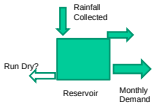
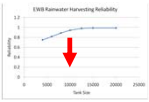
## 2. Introduction to Design – Rain Water Harvesting Case Study




- *Understand* "real" problem to be solved
- Define relevant and important design criteria
- Check feasibility (basic 'sanity check' too)
- Determine key parameters using analysis and modeling
- Don't forget '*other*' factors (e.g. social and cultural factors)!





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## Review Questions: Rain Water Harvesting

1. What are the **key steps** you can suggest for solving an engineering design problem?
2. **Apply the suggested steps to the design problem** of your GNG1103 course project (before you begin, list your **assumptions** or **special considerations** that apply to your project).
3. Apart from the technical and economic issues, what **other issues** can influence a product design?



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## 3. Design Thinking


- **Empathize**
  - "Beginners mindset", "Digging deeper"
- **Define**
  - Problem statement: short, specific and sexy
- **Ideate**
  - Lots of ideas, sketch, iterate based on user feedback
- **Prototype**
  - Different kinds of prototypes used at different stages in the design process and for different purposes
- **Test**
  - Iterate quickly and effectively

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## Review Questions: Design Thinking

1. What is **design thinking**?
2. When is the **beginner's mindset** applied in design thinking and why is it important?
3. Describe the **steps** of the engineering design process model called **design thinking** as it may be applied to your GNG1103 **course project**.
4. From the statements below, circle the single true statement

   Design thinking is a engineering design process model which emphasizes on:

   A. Empathy and testing
   B. Problem definition and prototyping
   C. Empathy and rapid ideation
   D. Prototyping and iterative testing
   E. Empathy and rapid iterative prototyping
   F. Ideation and rapid iterative prototyping



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## 4. Need Identification and Problem Identification

- Difference between Customer and User
  - Definition of "Lead users" and three different types
- Basic Steps:
  1. Gather and interpret data (Who?, What? and How?),
  2. Organize and prioritize needs (grouping, number weights)
  3. Reflect on results
- Problem Statement focuses design activity
  - **What** problem? **What** is the need?
  - **Who** has the problem or **who** needs solutions?
  - **Form** or **scope** of final solution?



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## Review Questions: Need Identification & Problem

1. Describe the **process of customer needs identification** in engineering design.
2. What is the difference between a customer and a user? What is a **lead user**?
3. What are the considerations for a good interview as applied to the **client of your course project**?
4. What is a **problem definition**? List the **attributes** of a good problem statement.
5. Among the needs statements below, identify the good or bad ones

   A. The stretcher must be controlled mechanically
   B. The stretcher can be easy to stop
   C. The customer needs an affordable stretcher
   D. The stretcher can be portable and storable

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## 6. Design Criteria

- Functional vs non-functional
- Constraints
- Metrics
- Benchmarking
- Design Specifications
  - Ideal vs Acceptable

| Rescue Device / Specifications | Importance (weight) | Squadra Patrol Toboggan #231 | Cruiser SS | Franco Garda Stretcher |
|---|---|---|---|---|
| Company | | Traverse Rescue | Cascade Rescue | TSL Rescue |
| Cost | 2 | 3 | 2 | 1 |
| Weight | 3 | 2 | 1 | 3 |
| Stored Size | 2 | 1 | 2 | 3 |
| Braking System | 5 | 2 | 3 | 2 |
| Steering Assistance | 5 | 2 | 2 | 3 |
| Total | | 34 | 36 | 42 |

| | Design Specifications | Relation (=, < or >) | Value | Units | Verification Method |
|---|---|---|---|---|---|
| | Functional Requirements | | | | |
| 1 | Transport a person across snowy terrain | = | yes | N/A | Test |
| 2 | Weight supported | > | 250 | lbs | Analysis, final test |
| 3 | Fail-safe braking | = | yes | N/A | Test |
| 4 | Gradient braking | = | yes | N/A | Test |
| 5 | Quick set-up time | < | 5 | min | Test |
| 6 | Stability (stretcher shape) | = | yes | N/A | Test |



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## Review Questions: Design Criteria

1. What is a **design criterion** and what is a **metric**?
2. Define the concept of **target specifications** and describe the steps of the **engineering design specification process**.
3. List two **types of benchmarking data**. What is the importance of benchmarking in engineering design.
4. Determine the **best solution** among the three proposed solutions using the data in the following table.

| Rescue Device / Specifications | Importance (Weight) | Squadra Patrol Toboggan #231 | Cruiser SS | Franco Garda Stretcher |
|---|---|---|---|---|
| Company | | Traverse Rescue | Cascade Rescue | TSL Rescue |
| Cost | 5 | 3 | 2 | 1 |
| Weight | 3 | 2 | 1 | 3 |
| Stored Size | 3 | 1 | 2 | 3 |
| Braking System | 5 | 2 | 3 | 2 |
| Steering Assistance | 5 | 2 | 2 | 3 |
| Total | | | | |



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## 7. Team Dynamics and Conflict Management


- Team diversity ***can*** be an asset, but …
- Conflict Resolution is important:
  - Prepare by: acknowledging, discussing and communicating
  - Understand situation (clarify, list facts and assumptions, analyze in smaller groups and then re-convene to discuss)
  - Reach agreement: Define course of action and a plan
- Different natural personality styles
  - Each works better in different situations (Q: What are these?)
  - No "wrong" or "bad" personality type, but there are better ones for specific situations

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## Review Questions: Team Dynamics & Conflict

1. As a member of a design team, you are well aware that conflicts can arise within the team at any time. In case of conflicts, what are the steps in the **resolution process** that you would follow?
2. List **four elements** that influence the **choice of conflict management style**.
3. For each conflict statement in the table below, associate the most appropriate **conflict management style** and justify your choice.

| # | Conflict Statement | Appropriate Conflict Management Style |
|---|---|---|
| 1 | You are in a team of 5 engineering designers. One of your team members always arrives 5 minutes after the start of your weekly team meetings which takes place every Friday at 7pm. The delay does not affect the progress of the project and the meeting. | |
| 2 | You work in a team on your design engineering course project. You must submit a deliverable in less than 24 hours and one of your teammates did not do his tasks that should be included in the deliverable. | |
| 3 | You work in a team on a project and your task depends on that of a teammate who has not started yet. You still have enough time to complete your task. | |



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## 8. Conceptual Design and Ideation

- Idea generation is a ***divergent*** process
  - Creative one too!
  - Sketching and different types of sketches
  - Block diagrams (Basic "control loop" block diagram example)
- Brainstorming
  - Individual process ("crazy" ideas OK; suspend own self-judgement)
  - cross-stimulation to 'amplify' ideas and make it more divergent,
  - suspend judgement, as a team
  - formal setting and organization important (e.g. chairman role)



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## Review Questions: Conceptual Design & Ideation

1. What is **ideation** in engineering design?
2. List and describe **two documentation tools** used in engineering design?
3. Using the **important** design criteria of your course project, produce at least **three preliminary design concepts** that could address your problem statement.
4. In the table below, indicate whether the statements are true or false.

| # | Statement | True/False |
|---|---|---|
| 1 | Finding the right solution in engineering design is only a convergent process. | |
| 2 | During the brainstorming session, judgements shall be suspended | |
| 3 | Brainstorming in engineering design means generate ideas, suspend judgements and formalize framework. | |
| 4 | Conceptualization does not involve analysis and choice of a concept. | |



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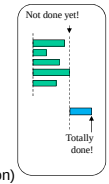
## 9. Time and Project Management




- Projects of *any* complexity require planning
  - Also require monitoring, after execution starts, too
- Personal Time Management
  - "To Do" List (*What*)
  - Deadlines (*When*)
  - Importance determined (*Why* analysis will enable prioritization)
  - Multi-tasking ***costs*** time because of context switching overhead
  - More important in a team setting because of dependencies
- Project Time Management
  - Define all tasks, estimate their duration (e.g. planning poker, **half-way between average and worse case**) and then assign them to individuals, noting inter-task dependencies (e.g. Gantt chart)
  - Risks should be defined and contingency plan created
  - Project cost depends on labor cost, overhead and material cost (BOM)



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## Review Questions: Time & Project Management

1. What is **project management**? What is a **Gantt chart** used for?
2. Produce a Gantt chart of the project your GNG1103 course.
3. In the table below, indicate whether the statements are true or false?

| # | Statement | True | False |
|---|---|---|---|
| 1 | Project management involves personal time management, organization and planning. | | |
| 2 | Learning project management skills is only necessary for unorganized people | | |
| 3 | Personal time management as well as project management requires effort and time. | | |
| 4 | In order to save time in project management, it is highly recommended to work in multitasking mode. | | |
| 5 | In project management, Gantt chart can help to visualize tasks duration. | | |
| 6 | A to-do list is a valuable tool for project plan or schedule. | | |



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## Course Attendance: Registration

- Use your smartphone or laptop to **register/notify** your attendance in this lecture
- Allow **geo location** in the attendance site
- Accept **cookies** from third parties applications
- Log in using only your **Uottawa** account at the link below
  https://attendance.azarm.ca/attendancerecord/gng1103f
- Your attendance must be registered only **during the lecture** and at the **time specified by the professor**
- You can also use the **QR code** below, to register quickly

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## 10. Engineering Design Analysis


- Scientific principles and analysis techniques
  - ⇨ Predict and prevent failures
- General analysis process of ski hill rescue device:
  1. Determine list of components/materials to meet target specifications (use available or commonly-used components to save cost or use new material for strategic reasons)
  2. Use values of properties (metrics) to calculate specific values
  3. Compare with target specifications… and repeat steps 1-3
- Use prototypes (different *types* of these!)
- Use *existing knowledge*, but identify and fill "gaps"



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## Review Questions: Engineering Design Analysis

1. Define **engineering analysis** and describe its **general principle** and **usefulness**.
2. Describe the **four steps of the engineering design analysis** used for the ski hill rescue device case study.
3. In the table below, indicate whether the statement is true or false.

| # | Statement | True/False |
|---|---|---|
| 1 | Engineering design analysis is useful only during the conceptualization phase of design thinking. | |
| 2 | The analysis is helpful for predicting results and preventing failures in engineering design. | |
| 3 | Experimental prototyping cannot be used for engineering design analysis. | |
| 4 | Seeking the simplest solution and required information is important in engineering design analysis. | |
| 5 | A good engineering designer shall always be able to justify the components and materials selected for his/her design. | |



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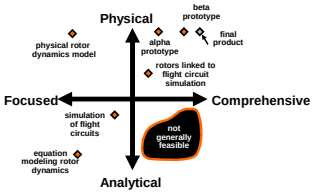
## 11. Prototypes




- Focused vs Comprehensive:
  - Model selective design aspects vs whole thing
  - Different levels of detail possible
- Physical vs Analytical:
  - Cost, fidelity, flexibility and complexity are traded off differently
- Attributes of good prototypes: Fidelity, cost, iteration time et SNR

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## 11. Prototyping Plan and Personal Feedback

- Prototypes have multiple purposes:
  - Learn, communicate, reduce risk, performance measurement
- Need (one of the above) objectives for a prototype
  - Observe, measure, record, then interpret test results
- Personal Feedback has a basic format:
  - Sender should use neutral terms to describe the behaviour of the receiver and explain its effect on that sender
  - Should be specific and actionable
  - Should be timely and given only by the observer/ sender
  - Receiver *should* repeat the received message to the *sender*'s satisfaction, but does *not* have to change behaviour




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## Review Questions: Feedback & Prototypes

1. How **important is a personal feedback**? What are the **attributes of an effective personal feedback**?
2. Give two examples of productive feedback and two non-productive ones.
3. What is the **importance of prototyping** and **testing** in engineering design?
4. In the table below, indicate whether the statement is true or false.

| # | Statement | True/False |
|---|---|---|
| 1 | A neutral description of a behavior is always irrefutable. | |
| 2 | Prototypes can be classified along two dimensions. | |
| 3 | The attributes of a **good prototype** are fidelity, cost, iteration cycle time and signal-to-noise ratio. | |
| 4 | Comprehensive analytical prototyping is generally not feasible in engineering design. | |
| 5 | Before any testing, an adequate testing plan is essential as it can help to save time and money. | |



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## 12. User Experience Design


- Psychology and Sociology of Users important
- UX needs to be applied end-to-end (system level)
- Usability heuristics (Nielsen)
  - **Attention**: *Selective concentration on 'important' information*; People 'distracted' easily by complexity or poor organization; People don't multitask well; 7±2 !
  - **Memory**: *Process of storing and retrieving information (short or long term storage)*; Better to 'recognize', rather than 'recall'; Use familiar and consistent imagery
- Usability Analysis
  - Understand and analyze representative users and tasks
  - User differences can be summarized with *user personas*

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## Review Questions: User Experience Design

1. What is **experience user** design?
2. What is a **user persona** and what is it used for?
3. What is Jakob Nielsen's **usability heuristics** used for in engineering design?
4. In the table below, indicate whether Nielsen's usability heuristic is true or false.

| # | Jakob Nielsen's usability heuristics | True/False |
|---|---|---|
| 1 | The system status is visible. | |
| 2 | The system does not necessarily need to match the real world. | |
| 3 | The user should have the freedom to do and undo. | |
| 4 | Error preventions must be ensured. | |
| 5 | The user must remember stuff. | |



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## 13. Modeling to Understand

- Modeling can help: reduce costs, increase design quality or even document "lessons learned"
  - **Basic issues and Trade-offs**: Assumptions, Constraints, Time Requirements, Fidelity, conceptualization, requiring planning (with defined objectives, etc.)
- Modeling Techniques:
  - **Analytical**: Typically mathematical (closed-form solutions)
  - **Numerical**: Typically computer-based (computationally demanding where extrapolation is desired)
  - **Experimental**: Physical with real-world measurements (good when other methods too hard, but can have 'noise' issues)



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## Review Questions: Modeling

1. What is a **model**?
2. List three **modeling techniques** and their advantage.
3. What is the **value of models** in engineering design?
4. In the table below, indicate whether the statements are true or false.

| # | Statement | True/False |
|---|---|---|
| 1 | Understanding assumptions, concepts and constraints is important for modeling. | |
| 2 | Modeling is only useful for performance analysis. | |
| 3 | Developing a technical model may include building both analytical and physical models. | |
| 4 | FEA is used for experimental models. | |
| 5 | Numerical models rely on discretization. | |
| 6 | Modeling noise makes learning effective. | |

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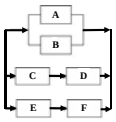
## 14. Failures and Iterative Testing




- Failure Types:
  - Not working at all
  - Not working right
  - Breaking (i.e. won't work again without repair or replacement)
- Critical Failure Handling requires component redundancy
  - Reliability engineering basics (e.g. series and parallel components)
- Designers need to *handle* failures, requiring:
  - Failures be detected
  - Failures be predicted
  - Failures be prevented, or (if not possible)
  - System recovery from failures



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## 14. Failures and Iterative Testing

- Testing: Desired level of performance measured (or not!)
  - Boundary cases or extremes (e.g. testing to failure)
- Basic Testing Process is iterative
  1. Define objectives and type of prototype
  2. Determine fidelity
  3. Make appropriate assumptions
  4. Plan execution
  5. Execute tests (observe and record; investigate 'surprises')
  6. Analyze and interpret results
- Risks and Uncertainties must be handled too
  - Add design margin
  - FMEA



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## Review Questions: Failures & Iterative Testing

1. **Handling failures** takes into account three or four **considerations**. List these considerations.
2. Calculate the **probability of failure and operation** of a system composed of two subsystems A and B in series with failure probabilities 0.1 and 0.2 respectively.
3. What are the two ways of **handling failure uncertainty and risk** when failures cannot be eliminated by prototype testing?
4. In the table below, indicate whether the statements are true or false.

| # | Statement | True/False |
|---|---|---|
| 1 | The level severity, occurrence and detection defines the **RPN**. | |
| 2 | **FMEA** is a technique to manage projects and risks. | |
| 3 | Component failure can always occur with certain probability. | |
| 4 | Building and testing prototypes can help predict failures. | |
| 5 | With a RPN value of 130, a corrective action is required. | |

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## 16 Effective Communication: Non-Verbal


- Non-verbal communication very important!
  - Make eye contact,
  - Control and use facial expressions,
  - Use 'effective' hand gestures,
  - Watch your posture (e.g. stand up straight),
  - Movement (avoid "distracting" movements like pacing or swaying, putting hands in pockets, etc.)
- *Visual Aids* (e.g. prototypes) useful



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## 16. Effective Communication: Verbal


- Verbal communication obviously important too!
  - Be Clear, loud enough, expressive, *vary* the volume, use pauses or silences for effect (e.g. if asking a question)
  - Avoid unnecessary "filler" words like "Um", "Like", …
- Understand what your *audience* can understand and what they can or will "buy" from your presentation
  - TIRES motivating factors (and combinations of them!)
- Preparation, Planning and Practice important
  - Start and end well (**Who** are you; **what** is the problem; **just 'enough'** information on *your* solution and its uniqueness)
  - Handle questions properly (anticipate them too!)



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## Review Questions: Effective Communication

1. Engineering designers should also have communication skills. List **four qualities** of an effective presenter.
2. Any presentation has **three key structure levels**. List these levels while indicating the levels on which the presenter may pay particular attention.
3. List the **five buying drivers** any presenter should be aware of for communication or presentation.
4. In the table below, indicate whether the statements are true or false.

| # | Statement | True/False |
|---|---|---|
| 1 | 65% of communication is verbal. | |
| 2 | An effective display is simple, easy and pleasant to watch. | |
| 3 | A non-speaker is authorized to murmur in the presentation. | |
| 4 | Eye contact and facial expression are part of communication. | |
| 5 | Using jargon is highly recommended in communication. | |
| 6 | Communication skills cannot be learnt. | |

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## Central Topic Covered

- "Design Thinking" design process learnt and *practiced* from start to end
  - Modern Design Process used in industry now
  - Empathize, Define, Ideate, Prototype and Test
- Case Studies:
  - Rainwater Harvesting System,
  - Ski-Hill Rescue Device,
  - Golf Club Cleaner



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## Skills Learnt

- Skills (Individual Design *and* Team-based)
  - Team dynamics, conflict management, time and project management, giving and receiving feedback, user experience, effective presentations
- Labs re-enforce lecture skills and focus on *useful* skills for **both** university and industry
  - Microsoft Basics, Basic Sheet Metal Processing, Arduino process control, Solidworks, Matlab, User Experience, Electronic soldering and Laser Cutting.



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## Advices: Considerations for Effective Learning

What is your **Concentration** & **Retention** time?

1. Do you ask experts (prof.) for advices?
2. How many time do you spend when studying?
   Chunk technique (15 to 25 minute learning + 5 minute break)
3. Where do you study?
   Avoid bed, game room, kitchen or living room. Use study light
4. What do you study?: Concepts or Facts?
   Study concepts not facts (John Edward Arnold is one of the founding fathers of Design Thinking)
5. Do you take notes and flesh them out?
6. Do you rest your brain enough?
7. Do you repeat often or teach other people?
8. How do you read your lecture notes or text books?
   Survey – Question (how, what, where, why, when) – Read – Reformulate – Review (SQ3R) periodically
9. How do you memorize facts?
   Acronyms (SQ3R) – Coined phrase (screw & unscrew) – Image (Protein-Carbohydrate-Fat **449**)
10. Do you relate new concepts learnt to what you know?