

# Continuity and Engagement in an Open Ecosystem: Challenges and Approaches

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# Continuity and Engagement in an Open Ecosystem: *Challenges and Approaches*

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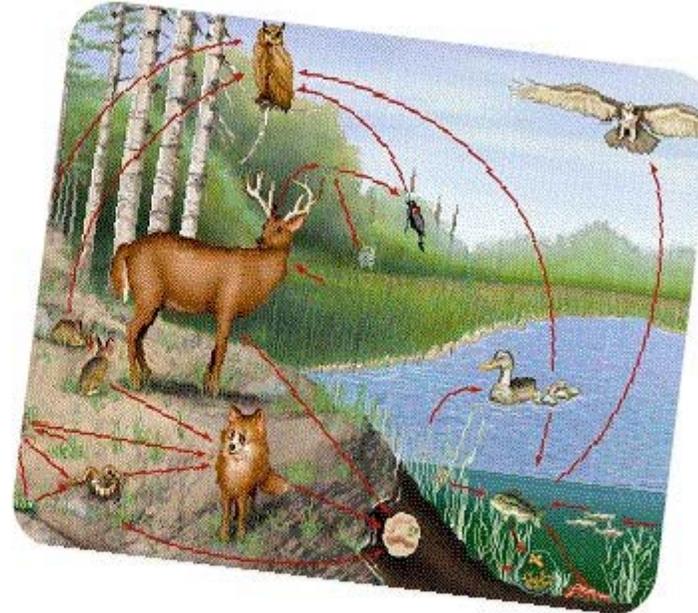
# Open Ecosystems: What are they good for?

**ECOSYSTEM** – basic unit and probably the most important concept in ecology

## Two Types of System:

1. **Open system** –  
presence of inputs  
and outputs (matter  
and energy)

2. **Closed system** –  
no exchange of  
matter and energy  
(usually artificially  
made, e.g.  
terrarium)



**Except for the universe, all natural systems are OPEN!**

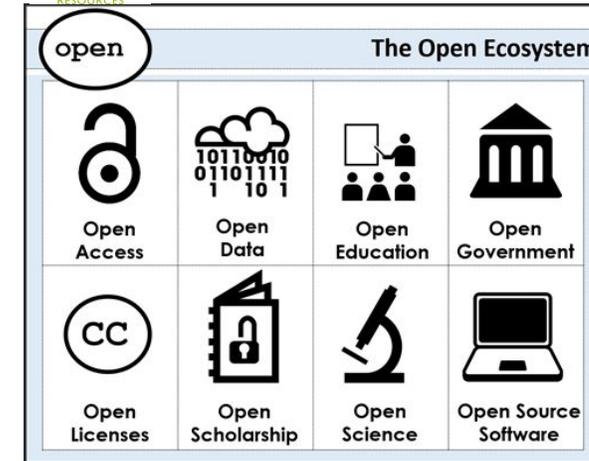
Source: Parungao, 2010: <https://www.slideshare.net/lhenparungao/lecture-1-ns-5-ecology-and-ecosystem-concepts-2010>

# Open Ecosystems: What are they good for?

## Benefits: Evolution

- Reproduction
  - New things (distribution)
  - Reuse
  - Reputation
- Mutation
  - Collaboration
  - Adaptation & Remixing
  - Assembly
- Competition
  - Evaluation/Ratings
  - Marketplaces

## Examples



Source: clobridgeconsulting.com

# Open Ecosystems: Problems

## Challenges

- Continuity

- Technical I/O

- Grain size



- Semantics/data meaning



- Tone/glossaries



- Narrative flow

- Identity

- % Authorship/N-finite authors



- New vs. revised artifact

Teachers Pay Teachers

- Community Building

- Content producer incentives



WIKIPEDIA  
The Free Encyclopedia

- Cold start problem

# Open Ecosystems for Education/Training Content

## Repositories/Marketplaces:

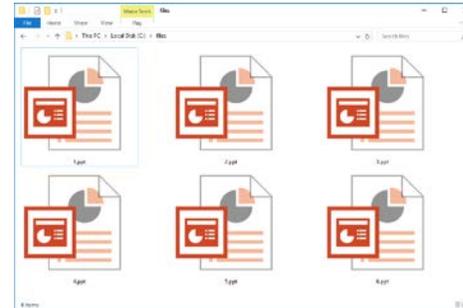
- Teachers Pay Teachers
- Open Educational Resources
- Amazon Inspire

## Open Platforms

- Wiki (Wikiversity, Wikipedia, WikiEducator)
- WikiHow
- YouTube
- MOOC (EdX, Coursera, Udacity)

## Registries of Links:

- Learning Registry variants
- Mason OER Metafinder
- Google search



# Sequencing Resources

## Not Adaptive

- **Linear:** Hand-crafted set of activities
- **Hypermedia:** Navigate through tree/links/search

## Hand-Crafted Adaptive

- **Place-Out:** Skip parts by doing well (in linear/links)
- **Branching:** Hand-made if-then rules/states
- **Assignments:** Teacher assignment to class based on pace

## AI/Machine Learning

- **Recommenders:** Select next problem or system
- **Problem Generators:** Injects/constructs practice exercises

# Sequencing Open Resources

## Benefits

- **Breadth:** Infeasible to re-invent the wheel on content
- **Running Start:** Leverage existing resources for new domain
- **Analytics:** Learn & apply empirically-effective resources
- **Varied Practice:** Deeper learning by using in multiple ways

# Sequencing Open Resources

## Challenges

- **Continuity:** Different terminology, activity types, goals
- **Engagement:** Maintaining “flow” when jumping around
- **Granularity:** Irregular resource size
- **External Links:** Many resources need custom “players”
- **Narrative:** Can resources be part of a broader goal/story?
- **Evaluation:** What \*is\* effective?

# Background & Motivation



## BACKSTORY

# Motivating Use-Cases

## Personal Assistant for Life-Long Learning (PAL3)



## GIFT Multi-Agent Architecture



## Service for Measurement and Adaptation to Real-Time Engagement (SMART-E)



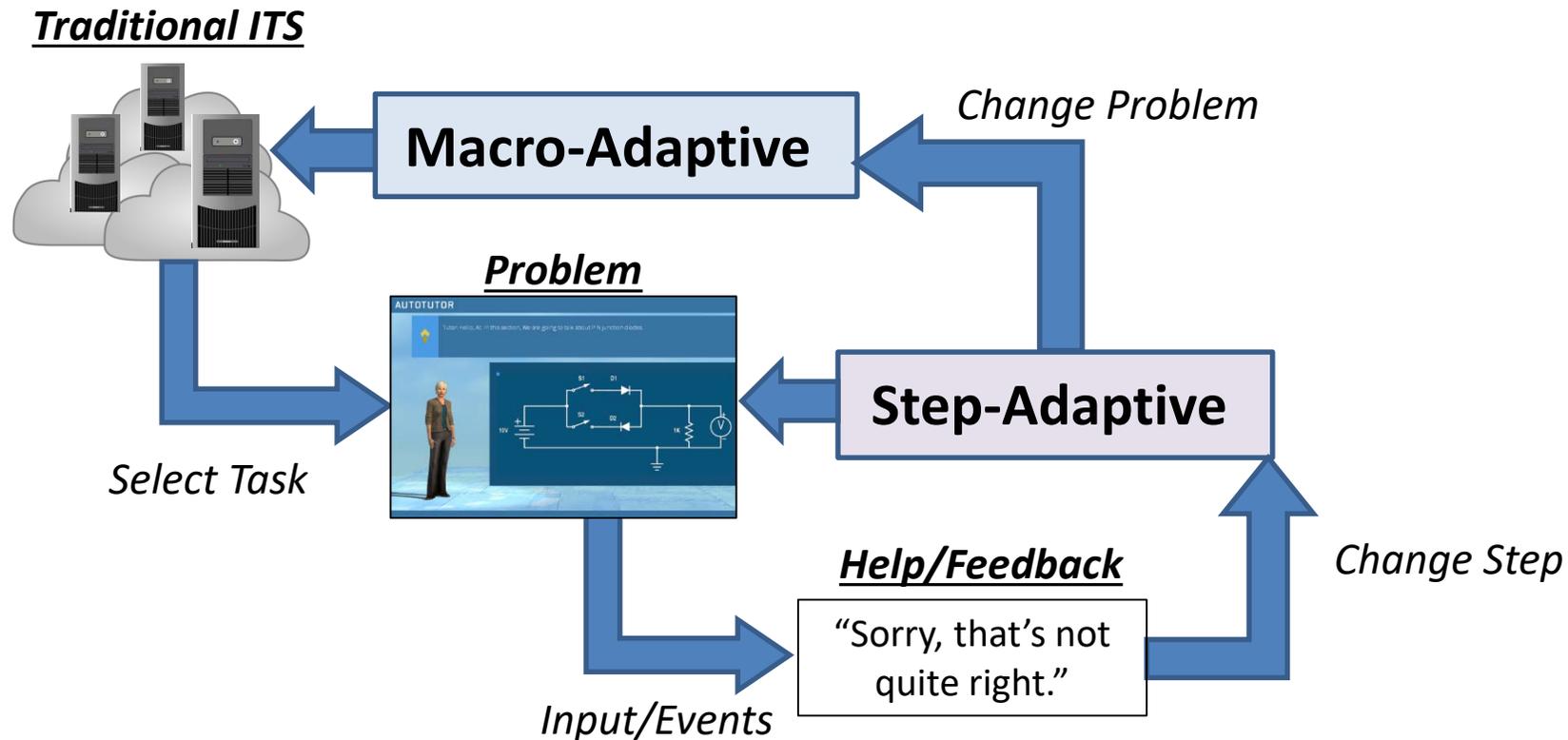
# PAL3 Project Goals



## A computerized personal assistant to help a learner:

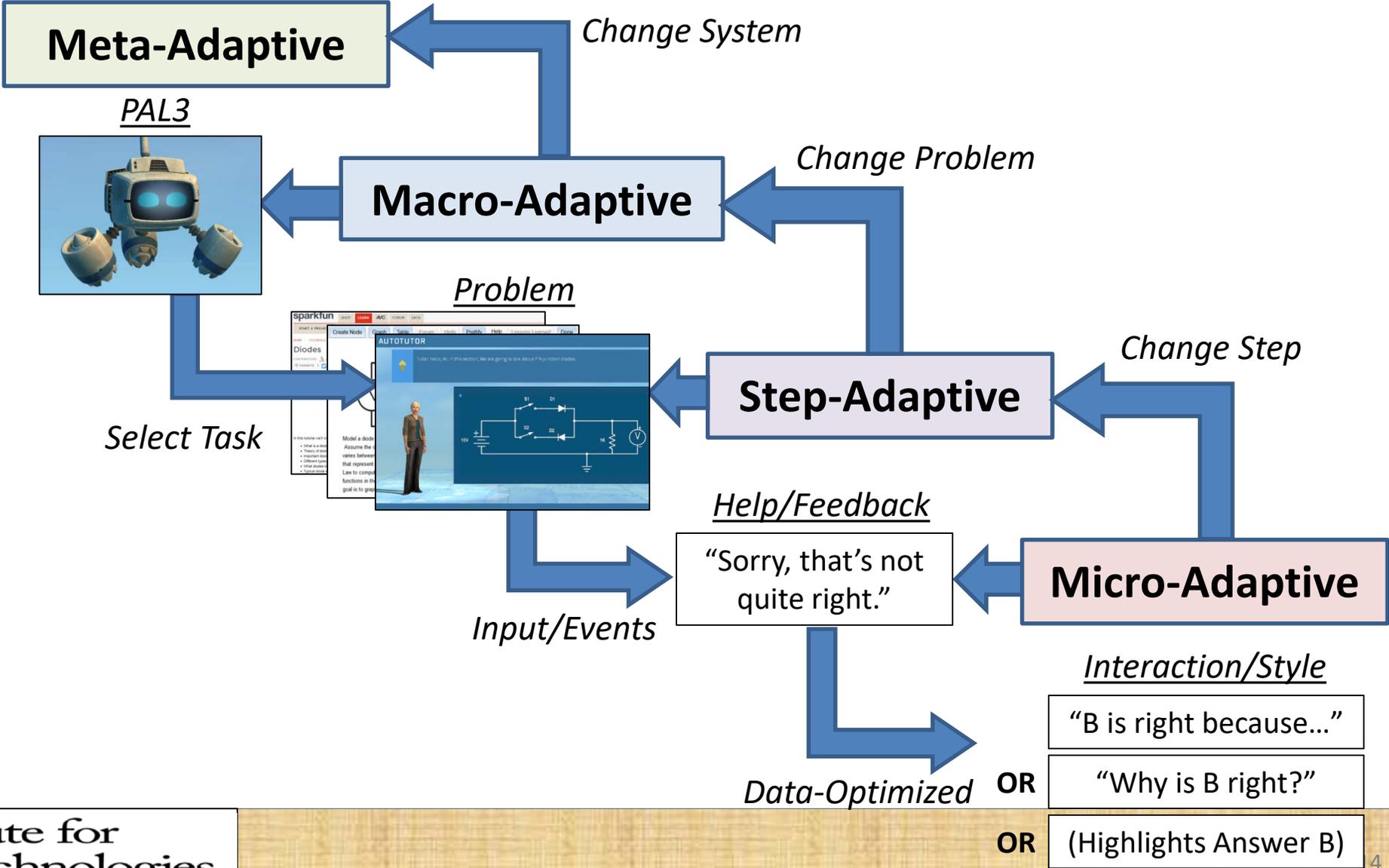
- Learn throughout their careers
- Successfully navigate career transitions
- Prevent skill decay
- Know their progress and mastery
- Adaptively find the right material at the right level
- Stay engaged: learn during free time

# Traditional ITS Approach



- For 20 years, most ITS have had 2 loops...

# PAL3 – Four Loop Adaptivity



# Personal Assistant for Life Long Learning (PAL3)

## Personalized Recommendations

3 factors: Novelty, Exploration, Deficits

The screenshot shows a user interface for a learning module. At the top, it says 'DIODE ACTION' and 'Mastery 11 on 3/5/2015 5:00:38 PM'. Below this is a list of tasks: 'Model a Diode' (20 XP), 'Diodes (Tutorial)' (1 pt), 'Diode Basics' (1 pt), 'Diode Assessment 1' (10 XP), 'Diode Assessment 2' (10 XP), and 'Diode Assessment 3' (10 XP). A robot character is on the left. A yellow box labeled 'LRS' is overlaid on the task list.

Guided Models & Simulations

The image shows a circuit diagram with a voltage source  $V_s$ , a diode, and a resistor. The current through the diode is labeled  $i_d$  and the voltage across the resistor is  $V_L$ . Below the diagram is a simulation interface with a 'voltage source' slider and a 'Source max volts' field. A 'Click here!' button is also present.

Existing HTML Links & Videos

The screenshot shows the Sparkfun website's 'Diodes' tutorial page. It includes an introduction, a list of sections (Introduction, Ideal Diodes, Real Diode Characteristics, Diode Applications, Resources and Going Further), and a list of topics to be covered in the tutorial.

Interactive Computer Tutoring

The screenshot shows the AUTOTUTOR interface. A virtual tutor character is on the left, and a circuit diagram is on the right. The circuit includes a 10V source, two switches (S1, S2), two diodes (D1, D2), a 1K resistor, and a voltmeter (V).

## Competitive Leaderboards

The screenshot shows a competitive leaderboard with columns for 'Ranking', 'Mastery', and 'User'. The top users are:

Ranking	Mastery	User
1	64	Z Z Tops
2	42	Bill Smith
3	37	Bahar Sh
4	32	At Test
5	23	Globa Stralou
6	15	Jon Webzel
7	7	Amo Startshot

## Achievements to Encourage Effort

The screenshot shows a user profile for 'At Test' with a list of achievements:

- Marianas Trench: Earn 2 badges when computing a resource (20 XP)
- Navy Green: Join the ML community (20 XP)
- Brave New World: Visit an external website resource (20 XP)
- Crawl, Walk, Run: Get a level (20 XP)
- Crowd Sourced: Submit a resource (20 XP)
- Zig-Zag: Hit the red home screen (20 XP)

# Recommender Basics

## How is content modeled?

- Goals: Real-life goals a person would want to achieve
- Focus Areas: Domain areas within a goal
- Topics: Groups of skills and resources to organize learning
  - Set of Lessons
  - Set of Knowledge Components
- Knowledge Components: Skills to learn
  - Mostly in: Structure/Behavior/Function taxonomy
  - Ex. Diode Behavior in Forward Bias
- Lesson: Ways to practice/study
  - One or more resources
  - Ex. 5 multiple choice questions; 1 video; 1 AutoTutor

# Recommender Basics

## How are recommendations made?

- Novelty: How much this resource has been seen?
- Exploration: How open-end is the activity the user must do?
- Deficits: How much could this increase the user knowledge?

# PAL3 Home Page



**HOME**

**John Young**  
Team Firebolt  
Level 5 XP 322

**Current Bonus:**  
+0 XP for resource completion  
0-day streak: Earn 25 XP to increase bonus to 1

**USER ROADMAP**

**USER PROFILE**

**LEADERBOARD**

**SUBMIT RESOURCES**

**RECOMMENDED TOPICS**

- Diode Action**  
A topic you haven't worked on yet
- RLC Circuits and Filters**  
A topic you haven't worked on yet
- Tutorials for PAL3**  
A topic you haven't worked on yet

**NOTIFICATIONS**

- makotrig completed 'Computer Security- Level 2'  
8/16/2017 10:48:23 AM
- ariajoie unlocked the Brilliance Skin by reaching level 22  
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- cassander completed 'History and Leadership'  
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- makotrig unlocked the Lazer Skin by reaching level 25  
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- audy completed 'Robotic Systems 1'  
8/16/2017 10:47:43 AM
- lazerted completed 'Introduction to 3D Printing'  
8/16/2017 10:47:43 AM

# PAL3 Continuity Challenges

- **Within Resources**
  - Lexicon: Navy using different terms/conventions than college courses
  - Duration: Some resources much longer than others
  - Unfamiliar Activities: AutoTutor and Dragoon
  - Challenge Level: Harder and more open-ended resources
- **Transitions/Handoffs to Resources**
  - External Resources: Return from URL links and installed applications
  - External Adaptation: External resources, bundles, or modules
- **Metadata about Resources**
  - No KC's: Resource added w/o knowledge components being known
  - KC Override: Resource might test different KC's than registered

# PAL3 Engagement Challenges

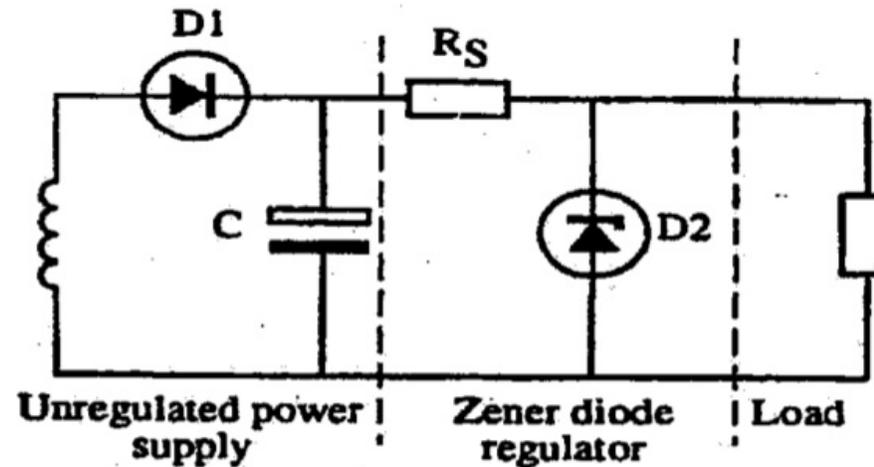
- **Trust in Recommendations**
  - Goals (Life) vs. Topics (Learning): What do I need these for?
  - Overconfidence: Didn't I already study these?
- **Social Influences**
  - Competition: Why compete if in the bottom half?
  - Activity Level: Why try if don't see others trying it?
- **Effort vs. Payoff**
  - Rewards: What do I get for working harder?
  - Effort Level: How much am I supposed to do per day?

# CHALLENGES: Continuity



# Challenges: Different Lexicon

- What happens to excess current?
  - Shunt
  - Dump
  - Sent to ground



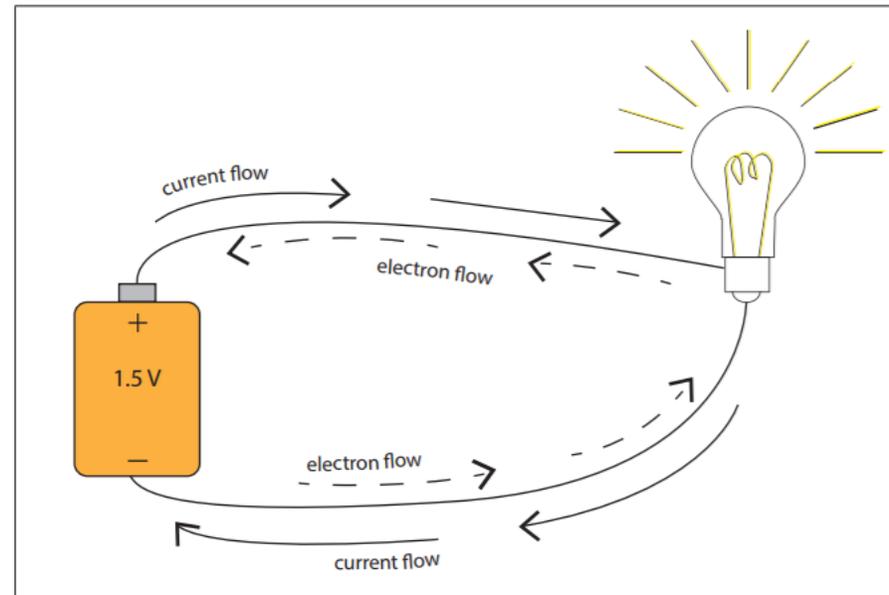
- What to do when your videos use “dump”, your text uses “sent to ground”, and your exercises use “shunt”?

# Approaches: Different Lexicon

- **Canon Version:** Make derivative content w/ one set of terms
  - Pro: Simple, fairly quick
  - Con: Content becomes “dead” (no live link to others’ changes)
- **Glossary Key:** Identify key terms and hotlink to a glossary
  - Pro: Can help learners map between terms
  - Con: Need a glossary for each domain. Need to detect/highlight?
- **Cliff Notes:** Brief docs, which note alternate terms
  - Pro: Useful to have a custom doc on each core concept anyway
  - Con: More passive content. User needs to do it, or is useless.

# Problem: Different Conceptualization

- Which way does \*current\* flow?
  - With the electrons
  - With the holes



- What to do when some resources may use a different (even opposite) concept of a key mechanism?

# Approaches: Different Conceptualization

- **Canon Version:** Make derivative content w/ one set of terms
  - Pro: Simple, fairly quick
  - Con: Content becomes “dead” (no live link to others’ changes)
- **Parallel Content:** Curate content for each framework
  - Pro: Could present different content progressions, which may share some resources
  - Con: Managing twice the content

# Problem: Different Granularity

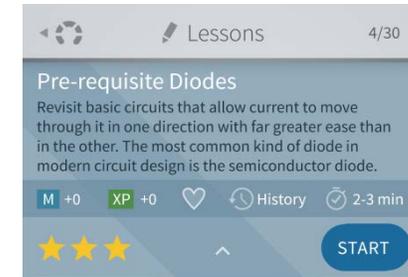
- How long will this lesson take?
  - 30 seconds
  - 3 minutes
  - 3 hours
  - 3 weeks



- What is a cutoff for expecting to return in the same session?
- How to deal with lessons with many resources in them?

# Approaches: Different Granularity

- **Set Expectations:** Show expected time to finish
  - Pro: Simple to get a rough-order-estimate
  - Con: Might vary for different users
- **Max Time Cutoff:** Don't recommend too-long resources
  - Pro: User knows what to expect in a system.
  - Con: Expectations differ by platform (mobile vs. laptop vs. desktop) and context (in-class, home).
- **Differentiated UX:** Different systems, same resource bank
  - Pro: Optimize system for different users & places
  - Con: Potential for confusion between open learner models



# Problem: External Adaptive Systems

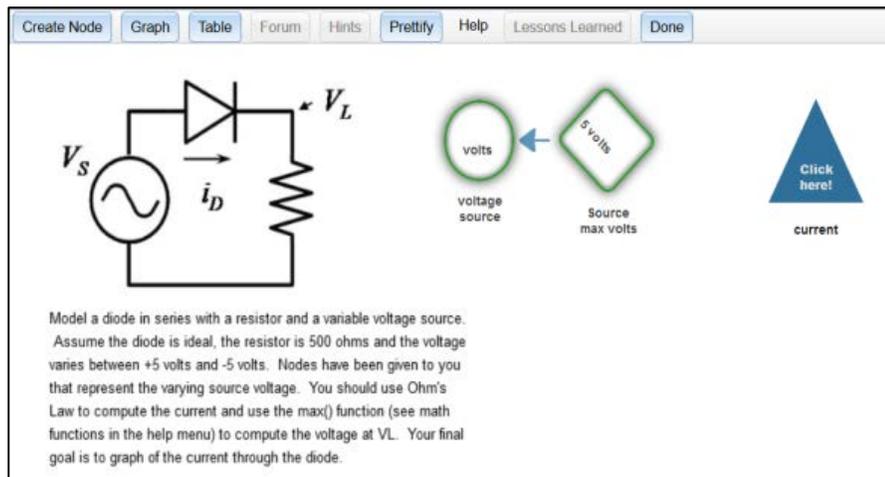
- What happens when we hand off to an external system?
  - 1 resource completed
  - N resources completed
  - ??? resources completed
  - 1 course completed
- How to deal with lessons with many resources in them?
- When should we wait for user to “finish” using an external system before recommending new things?

# Approaches: External Adaptive Systems

- **Bundle Resource:** Wait for special resource to “Complete”
  - Pro: External system can send many records before/after special one
  - Con: User will need to “Abort” to return, if special incomplete.
- **No Return:** Pool LRS records, but don’t wait for return
  - Pro: Allows asynchronous use of both systems
  - Con: Systems will look (and be) uncoordinated
- **Explicit Handoff:** External resource sends user back to source
  - Pro: Bidirectional coordination and referral (e.g., to resources)
  - Con: Stronger coupling and coordination required

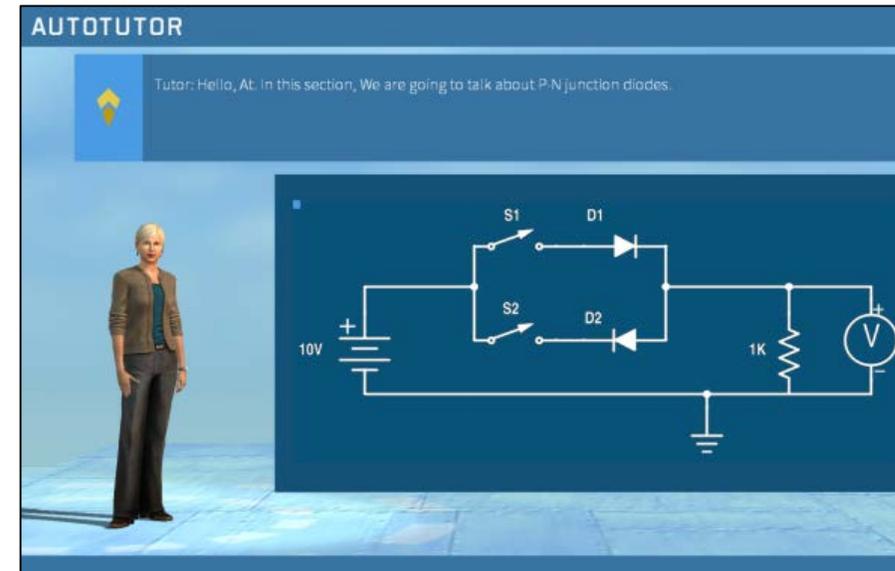
# Problem: Unfamiliar/Hard Activities

- What if some learning activities are novel (or exotic, even)?



The screenshot shows a software interface for circuit simulation. At the top, there is a menu bar with options: Create Node, Graph, Table, Forum, Hints, Prettify, Help, Lessons Learned, and Done. The main area displays a circuit diagram with a voltage source  $V_S$ , a diode, and a resistor. The current through the diode is labeled  $i_D$  and the voltage across the resistor is  $V_L$ . To the right, there are three icons: a green circle labeled 'volts' with 'voltage source' below it, a green diamond labeled '5-volts' with 'Source max volts' below it, and a blue triangle labeled 'Click here!' with 'current' below it. Below the circuit diagram, there is a text block:

Model a diode in series with a resistor and a variable voltage source. Assume the diode is ideal, the resistor is 500 ohms and the voltage varies between +5 volts and -5 volts. Nodes have been given to you that represent the varying source voltage. You should use Ohm's Law to compute the current and use the max() function (see math functions in the help menu) to compute the voltage at  $V_L$ . Your final goal is to graph of the current through the diode.



The screenshot shows an 'AUTOTUTOR' interface. At the top, it says 'Tutor: Hello, At. In this section, We are going to talk about P-N junction diodes.' Below this, there is a 3D character of a woman standing on a blue floor. To the right, there is a circuit diagram showing a 10V battery, two switches (S1 and S2), two diodes (D1 and D2), a 1K resistor, and a voltmeter (V). The circuit is connected to ground.

- What if learners get confused? What if some

# Approaches: Unfamiliar Activities

- **Tutorials:** Send users to tutorials before they hit new things
  - Pro: Most new resources can be understood in 2-3 minutes.
  - Con: Users are averse to general tutorials, so might need topic-specific ones. Users might skip tutorials.
- **Emulate Familiar:** Make new tasks feel like familiar ones
  - Pro: If done well, can result in better overall user experience
  - Con: Requires custom development per resource type. Only works if resource backend is distinct from its front end.
- **Alert/Warning:** Alert user that resource may be new or hard
  - Pro: Fairly simple to do. Sets expectations.
  - Con: Doesn't actually make resource easier

# Challenges: Partial KC Info

- What knowledge does this simulation test?
  - Takeoff
  - Landing
  - ... (it depends)

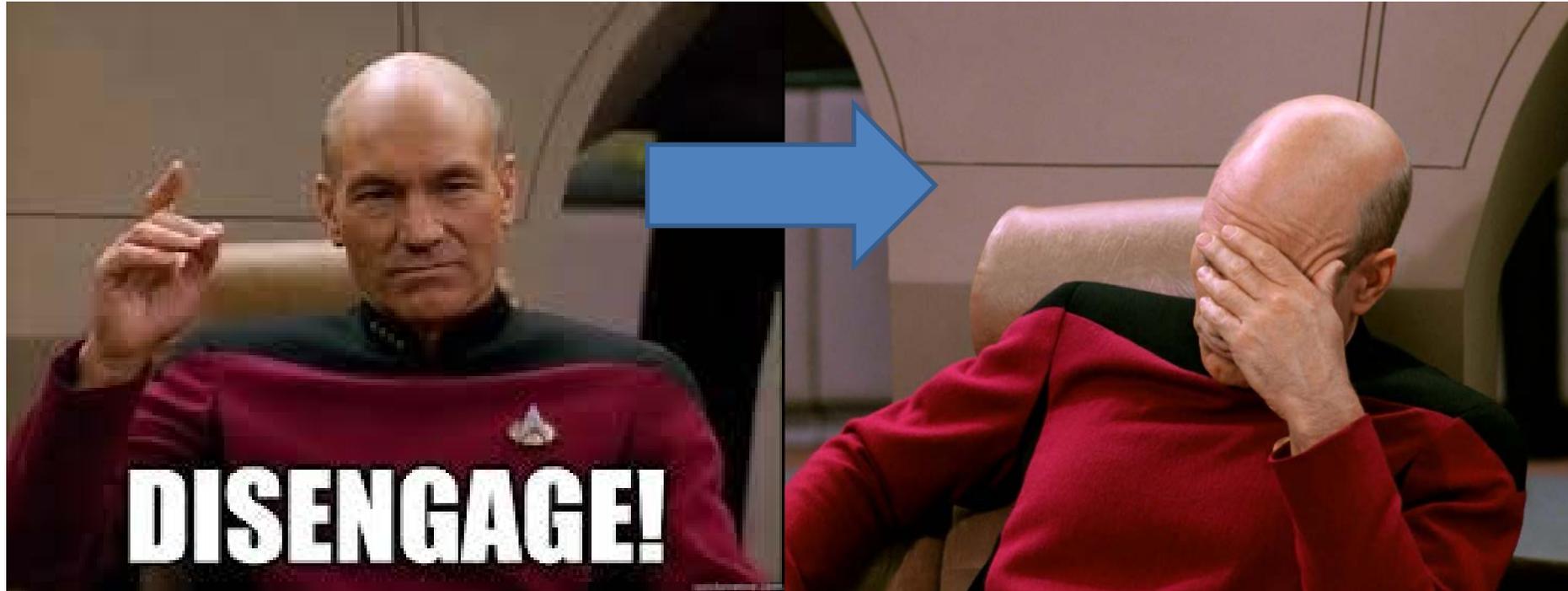


- What happens if someone adding a resource doesn't know its KC's?
- What happens if a resource tests different KC's depending on the user's decisions during it?

# Approaches: Partial KC Info

- **Register w/o KC's:** Allow adding and use, even w/o KC's
  - Pro: Allows layman instructors to add content.
  - Con: System has no idea when to recommend it or what it tests/helps
- **KC Override:** Allow external systems to override KC's tested
  - Pro: Resource creator should know what it tests best
  - Con: What if system sends an unknown KC? (Or all unknown KC's?)  
Also, no standard way to send this. Using xAPI extension, currently.

# CHALLENGES: Engagement



# Challenges: Trust in Recommendations

- Why was this topic selected for me?

The screenshot displays a user dashboard for John Young, a member of Team Firebolt at Level 5 with 322 XP. The dashboard includes a central 3D model of a robot, a left sidebar with navigation options (User Roadmap, User Profile, Leaderboard, Submit Resources), and a right sidebar with recommended topics and notifications. The recommended topics are Diode Action, RLC Circuits and Filters, and Tutorials for PAL3. The notifications list recent achievements by other users, such as completing 'Computer Security- Level 2' and unlocking skins.

**HOME**

**John Young**  
Team Firebolt  
Level 5  
XP 322

Current Bonus:  
+0 XP for resource completion  
0-day streak: Earn 25 XP to increase bonus to 1

**USER ROADMAP**

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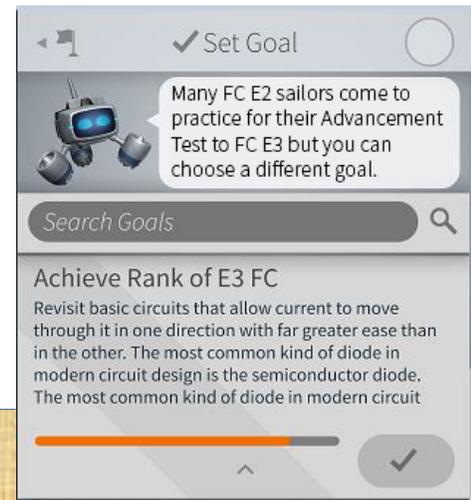
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- audy completed 'Robotic Systems 1'  
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- lazerted completed 'Introduction to 3D Printing'  
8/10/2017 10:47:43 AM

- What if I feel like I know this already?

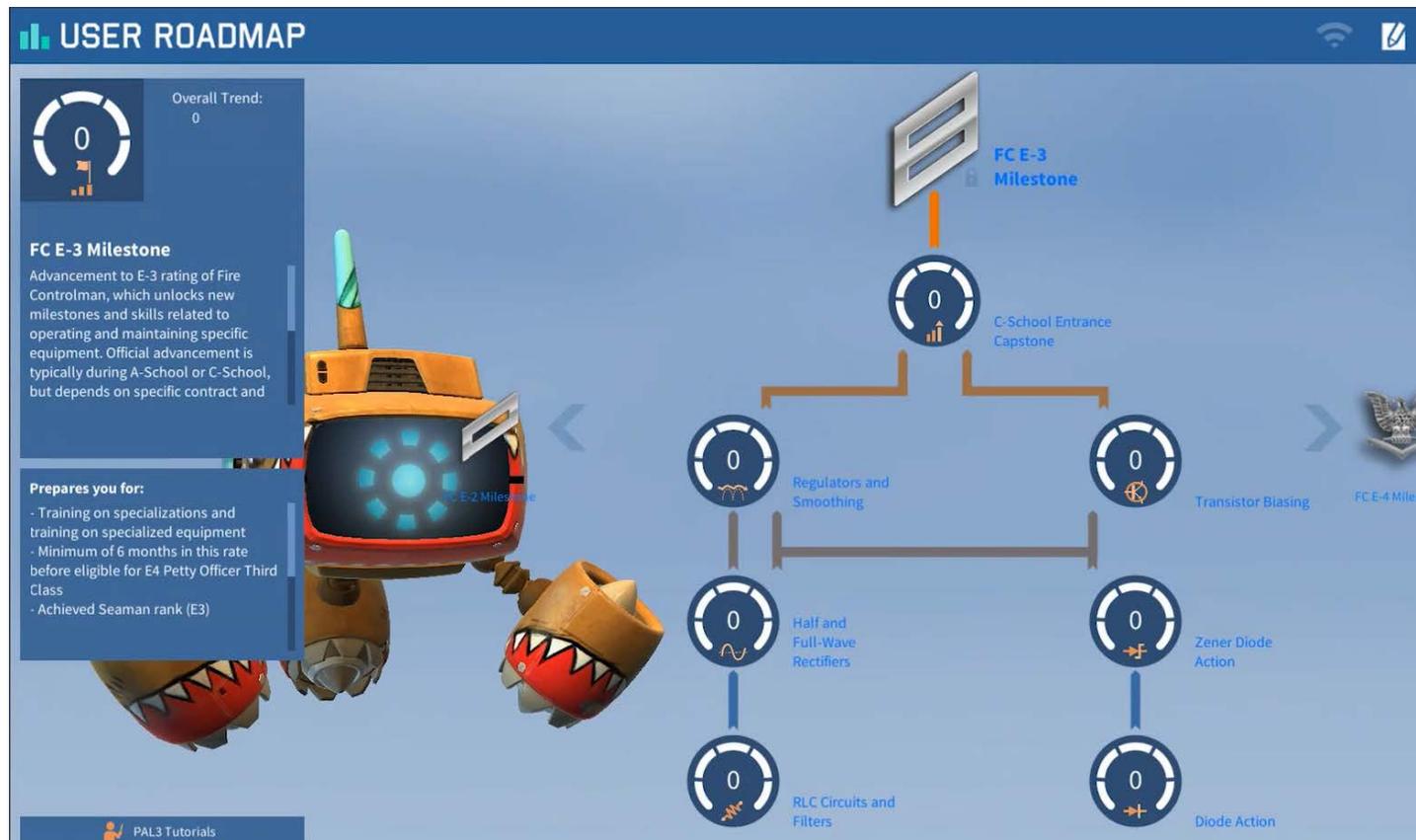
# Approaches: Trust in Recommendations

- **Pretest/Placement Test:** Comprehensive test upfront
  - Pro: Creates uncertainty and impasses->more ready to learn
  - Con: Barrier to getting started on learning immediately
- **Explainable AI:** Annotate recommendations w/ descriptions
  - Pro: Gives context about the resource
  - Con: Only usable with some types of recommender models. Reason for recommending may be not be useful to communicate (i.e., “You don’t know what the word ‘transitive’ means.”).



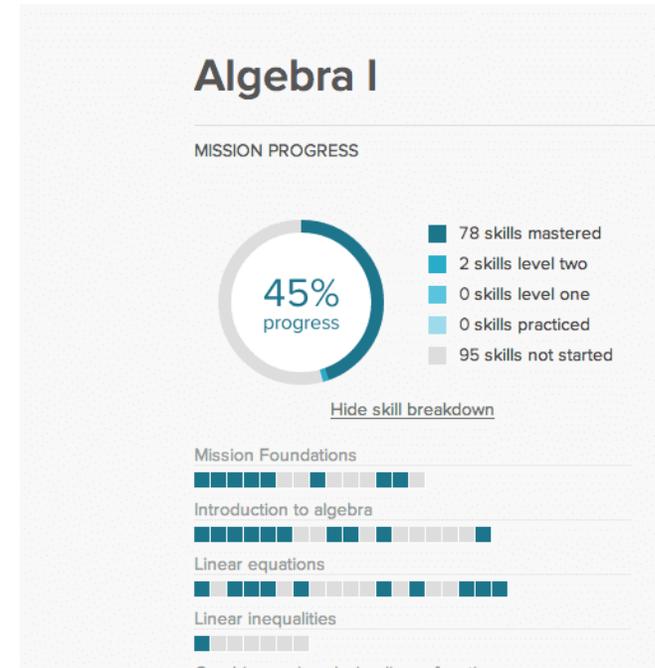
# Approaches: Trust in Recommendations

- **Roadmap:** Show “skill tree” of how learning builds to goal
  - Pro: Open learner model. Connect to authentic goal
  - Con: Non-trivial to lay out automatically



# Approaches: Trust in Recommendations

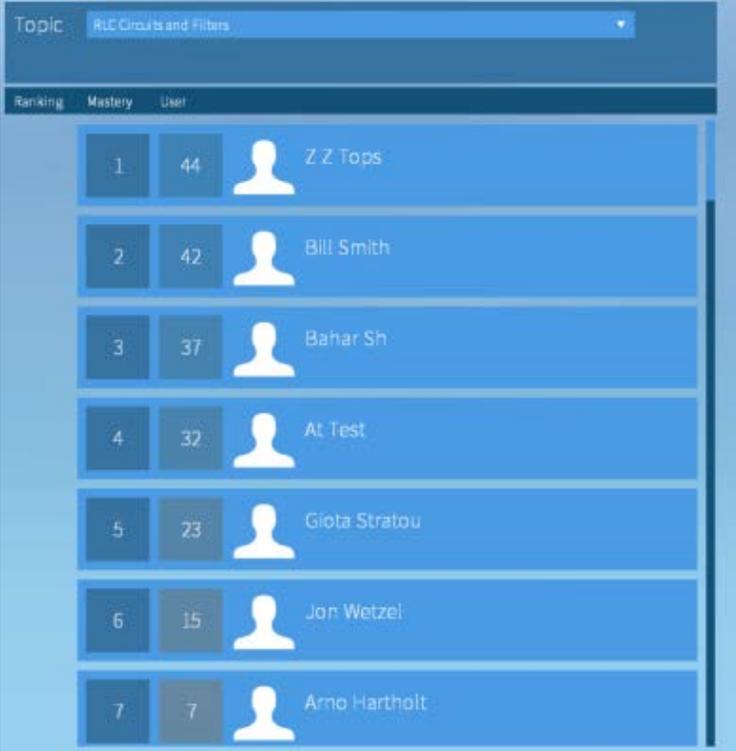
- **Goal Readiness:** Estimate of preparation for a real-life goal
  - Pro: Not a reward, but an indicator of authentic progress
  - Con: Hard to calibrate without real data on the goal. Just because you are ready for a goal doesn't mean you will accomplish it.



Khan Academy

# Challenges: Competition as Motivation

- What if I am not near the top of a leaderboard?



The image shows a screenshot of a digital leaderboard for the topic "RLC Circuits and Filters". The interface includes a dropdown menu for the topic, a table with columns for Ranking, Mastery, and User, and a list of seven users with their respective mastery scores and profile icons.

Ranking	Mastery	User
1	44	Z Z Tops
2	42	Bill Smith
3	37	Bahar Sh
4	32	At Test
5	23	Giota Stratou
6	15	Jon Wetzel
7	7	Arno Hartholt

- Who cares about the difference between 50<sup>th</sup> and 45<sup>th</sup>?
- What if I am embarrassed about my position?

# Approaches: Competitive Motivation

- **Show Top-N:** Don't show the whole group, only the top
  - Pro: Reduces risk of feeling highlighted if doing poorly
  - Con: Somewhat complex to implement with varied class sizes
- **Teams:** Group learners and compete/cooperate as teams
  - Pro: Lowest learners can add to team scores more quickly. Team standings make for good notifications/activity.
  - Con: Need a way to re-form teams if people drop out/disengage



The screenshot shows a 'LEADERBOARD' for the topic 'Diode Action'. It has a 'Group' filter set to 'Individual'. The table lists the top 5 performers with their rank, mastery score, name, and team.

Rank	Mastery	Name	Team
1	78	John Barry	Team Shark
2	71	Mako Trigg	Team Quail
3	64	Grace Hopper	Team Shark
4	52	John Young	Team Firebolt
5	43	Isaac Hull	Team Firebolt



The screenshot shows a 'NOTIFICATIONS' panel with three entries. Each entry includes an icon, a description of the achievement, and a timestamp.

Icon	Notification Text	Timestamp
Checkmark in box	Rick Sanchez completed Diode Action, Diode Resistor Circuit Cliff Notes increasing mastery to 10 and gained 5 experience points	3/5/2017 7:34:22 PM
Checkmark in box	Rick Sanchez completed Diode Action, Diodes (Tutorial) increasing mastery to 10 and gained 5 experience points	3/5/2017 7:46:16 PM
Cup icon	Mark earned the achievement Crawl, Walk, Run	3/3/2017 5:14:29 PM

# Challenges: Gamification/Rewards

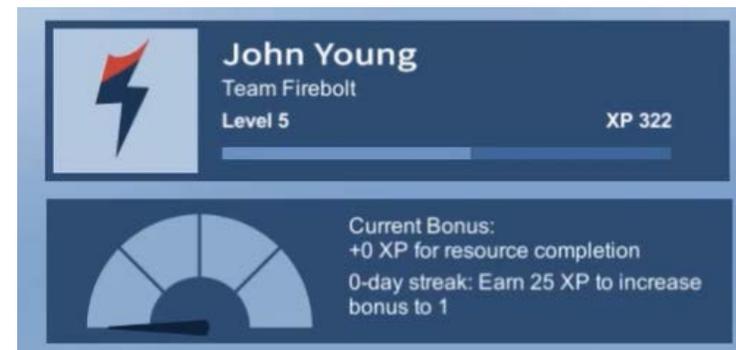
- Risks of Gamification: What is measured = what is done.



- How to ensure that rewards are aligned to learning goals?

# Approaches: Gamification/Rewards

- **Mastery Points:** Open learner model is a core metric
  - Pro: Total alignment to learning process.
  - Con: Yolked to open learner model. Can decrease.
- **Effort Points:** Reward time on challenging tasks
  - Pro: Increases with effort, even if struggling. Can use for level-ups.
  - Con: Can lead to gaming the system for points



# APPROACH: Personal Assistant



**Hi! I'm Flal!**

# PAL3 Design Criteria

## System Guidelines

1. Engage user.
2. Be an efficient use of user's time.
3. Guide user to what they need to focus on.
4. User must believe system is helping.
5. Reward user for using the system.
6. Provide user with an overview of their own learning.
7. Provide a variety of motivations to the user.

# Pal Character Design Criteria

## Design Guidelines – 5 Laws of Pal

1. Pal shall not get in the way of the user.
2. Pal shall be like the perfect butler.
3. Pal shall do things that are difficult for the on-screen GUI to achieve.
4. Pal shall reflect the user.
5. Pal shall create a desire to return to the system.

# Pal Character Roles

- **Goal-Monitoring:** Setting and tracking progress toward goal
  - Pro: Use dialog to connect completing lessons -> mastering topics -> achieving goals. Help to set new goals when done.
  - Con: Since goal is in real-life, can't see status of other factors
- **Support:** Positive messages for struggling users, growth mindset messages, etc.
  - Pro: Improve relationship & engagement for struggling learners
  - Con: Potential to be too “saccharine” for some users

# Pal Character Roles

- **Contextual Info:** Data on “users like you” or on-screen elements that would be hard to show on UI always
  - Pro: Useful for explainable AI and connecting effort to goals
  - Con: Data hungry, prioritization requires solid dialog management
- **Quotables:** Snark, inspiration, or other flavor text to enjoy
  - Pro: Breaks up a session, sometimes memorable
  - Con: Users respond very differently to different quotables

# Goal Setting Stages

- People set goals for at different time scales:
  - Long-Term (years):
    - Decisions: Who you are / Why you do it / Identity
    - Pathway Choice: Career Choice, Selecting a Rate
  - Medium-Term (weeks):
    - Decisions: How to reach a long-term goal
    - Milestone Choice: Role, Certification, Degree, Position/Rank
  - Short-Term (days):
    - Decision Made: What to do to reach a milestone
    - Topic Choice: What skills to build, What to study

# Goal-Setting Criteria

## Interests: How much do they want it?

- Infer from: Self-report, Rating tasks, etc.
- Importance: Self-initiative; Retainment

## Skills: How prepared are they?

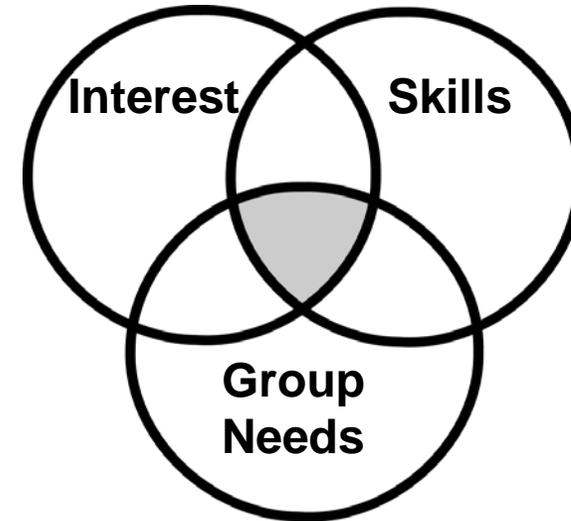
- Infer from: Learning records, Assessments (e.g. ASVAB)
- Importance: Time to train; Likelihood to reach criteria

## Needs: How much do others need it?

- Infer from: Unmet demand (e.g., projected unfilled posts)
- Importance: Force readiness; Ready relevant learning

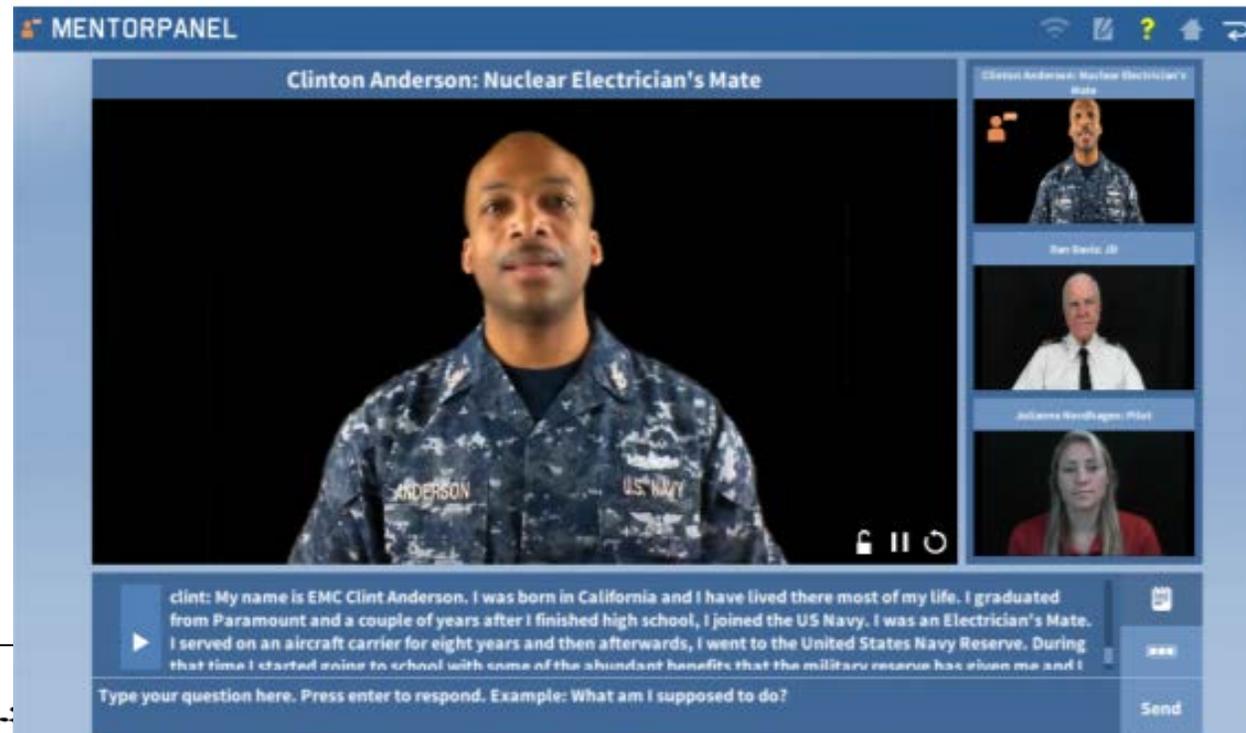
\* Multiplicative: Only as good as the weakest link

Note: Not all of these are suitable for a character like Pal

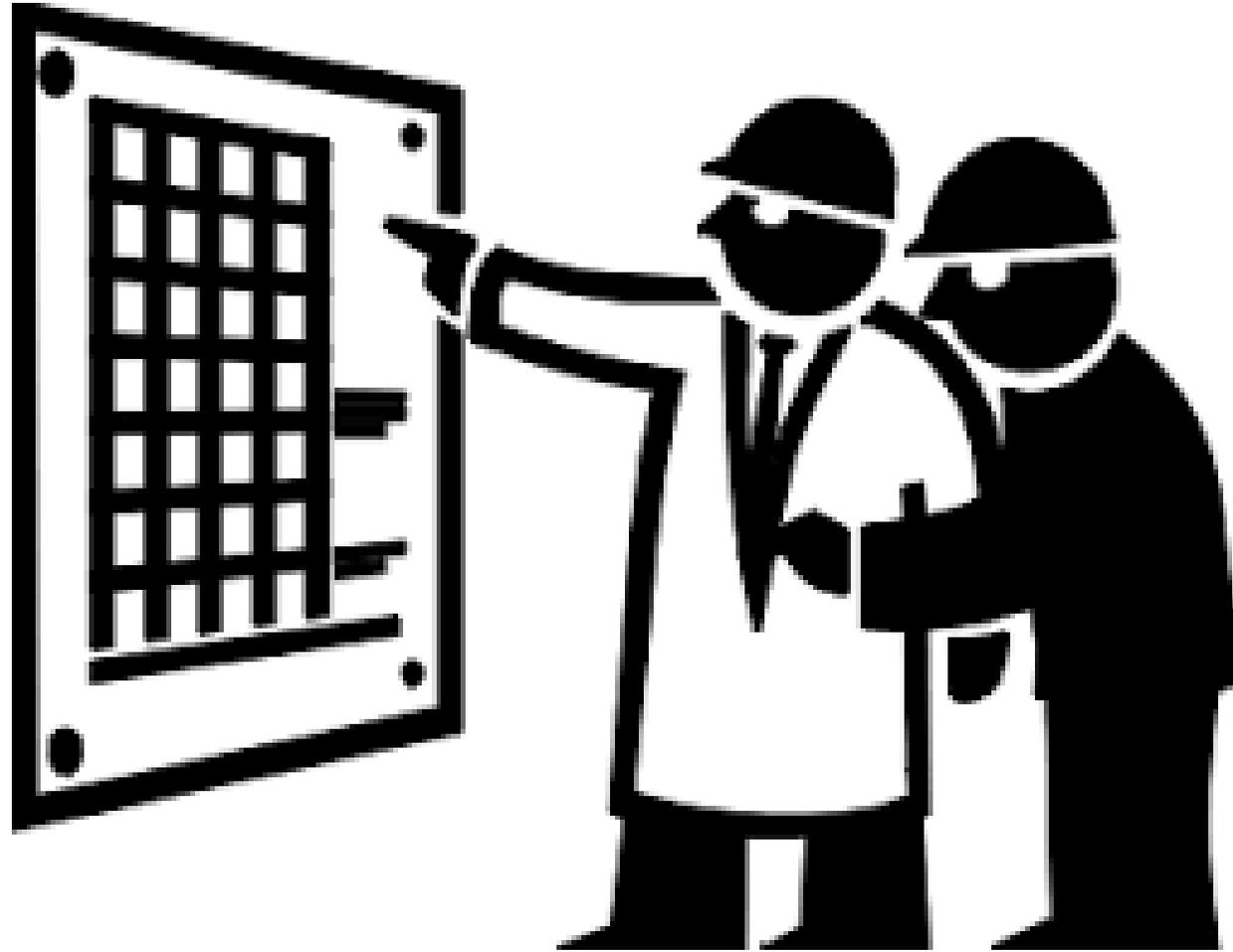


# MentorPal: Considering Career Paths

- Virtual Mentors in PAL3
  - Interactive Q&A w/ virtual mentors (one-on-one or panel)
  - Individual experiences, not a generic “career guide”
  - Realistic open-ended 5m-20m dialog
  - Compare answers from multiple mentors (MentorPal)



# WRAP UP: General Strategies



# General Strategies: Continuity for Resources

- **Moderated Resources:** Open resources but with moderation/curation that ensures areas with canonical language and shared user experiences (e.g., similar activities)
- **Annotated Resources:** Show information to help decide to use recommended resource (time, activity, content)
- **Lesson vs. Module:** Wait and acknowledge user return for lessons, but assume asynchronous use for large modules

# General Strategies: Engagement

- **Effort->Mastery->Goals:** Establish clear paths between effort on resources to mastery, and from mastery to their goals
- **Social/Competition:** Collaboration can be more powerful than competition. Teams of learners help bridge the two.
- **Rewards:** Weaker than motivation for goal-achievement and social ties. Useful for setting expectations for time-on-task.
- **Guides/Assistants:** Provide continuity for learning over time (e.g., “Welcome back”). Can use to message/reinforce productive mindsets. Challenging due to different user prefs.

# Questions & Discussion

