Toward a Generalized Appliance for Measuring Engagement & Motivation Across Learning Environments

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Framing the Problem
Maintaining Learning Engagement & Motivation

- USAF trains/educates large/diverse uniformed workforce
  - Academics can give airmen a content "fire-hose"
  - e.g. for aerospace maintenance:
    - many months of principles of mechanics, electronics
- In specialties w/potential shortages of critical personnel...
  - Mission critical to enhance training, maintain motivation/engagement
  - Engaging learning has mission-ready implications
- USAF delivering education w/interactive activities/games
  - But *does it work*? (are these activities motivating)
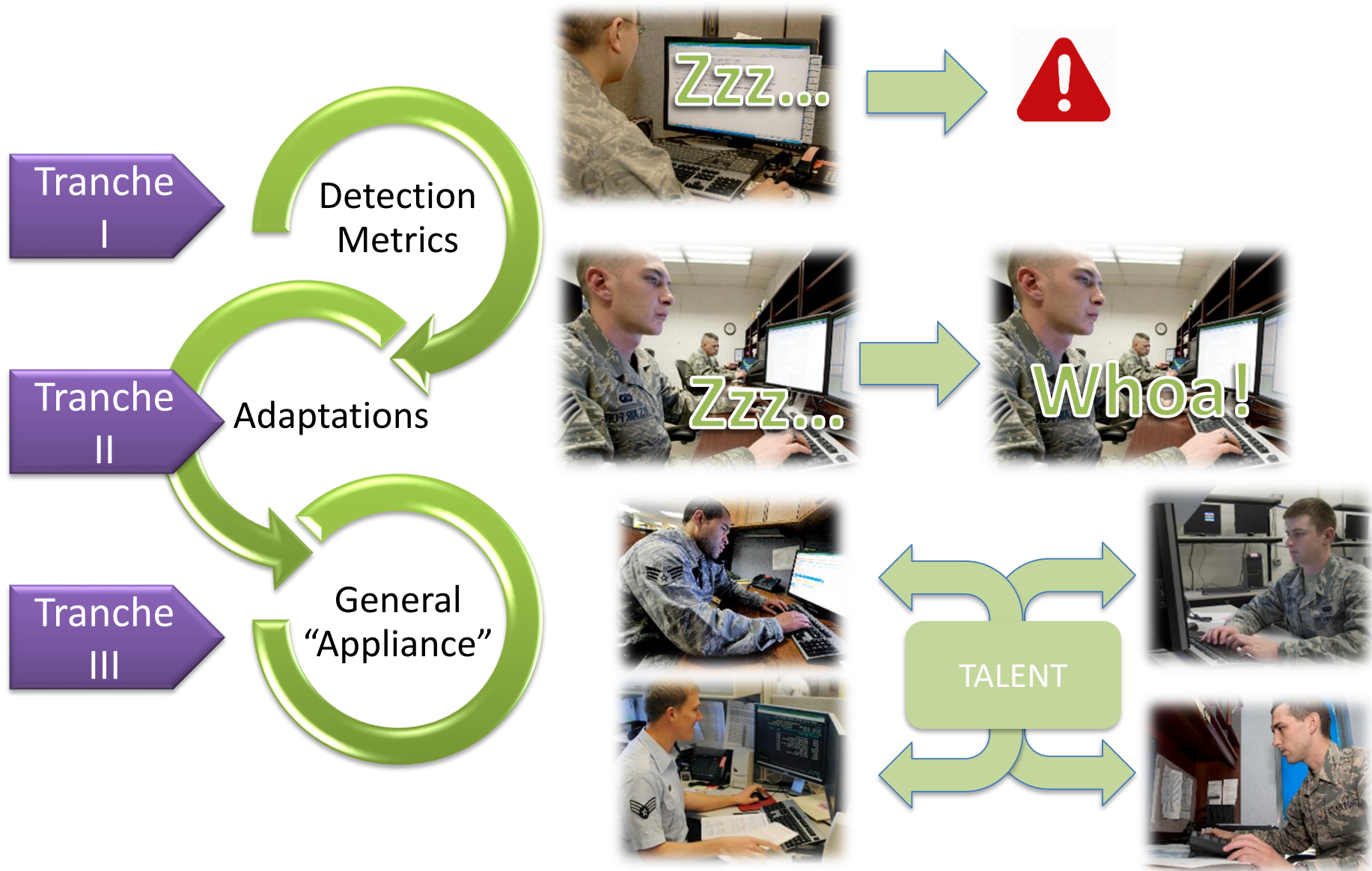 - How to detect & recover engagement lapses?

TALENT* Vision

- Across USAF, greater emphasis on digital learning environments
  - Need to identify which techniques offer most effective learning outcomes
  - Key elements in successful learning outcomes: engagement & motivation
  - Maintaining engagement & motivation remains a challenge
- Need learning systems that can
  - *Identify* lapses in engagement/motivation
  - *Adapt to* detected lapses

- Vision: A general-purpose *appliance* working across learning ecosystems
  - Advises learning environment of detected lapses
  - Recommends adaptive intervention to restore engagement/motivation
  - Collects data to help training managers improve learning outcomes

*Tracking and Assessing Learner Engagement Toolkit

Roadmap: Measure, Adapt, Generalize

Tranche I

Detection Metrics

Tranche II

Adaptations

Tranche III

General "Appliance"

Zzz...

Zzz...

Whoa!

TALENT

Measure first, Adapt second

- Goal: persistent and unobtrusive assessments to enhance the Air Force training and education enterprise with adaptive support for learner engagement

- Step 1: Measure Engagement and Motivation
  - Valid constructs, measures, software tools
  - Appliance to employ these metrics across a large community of training developers

- Step 2: Recommend adaptations

INTERVENTIONS

| Affect | Cognition/Study Habits | Motivation |

CONSTRUCTS MONITORED

Engaged Hours = f(Motivators, Demotivators)

Intrinsic
- Flow/enjoyment
- Performance/Success
- Evasion: Avoid failure

Extrinsic
- Frustrations (bugs, delays, no visible progress)
- Social conflict
- Hunger/discomfort

Intrinsic:
- Safety (life-saving info)
- Self-Actualization (mastery, career goals)
- Social (peers, instr.)

Extrinsic:
- Mandatory vs. Punished
- Performance incentives

METRICS RECORDED

Inner Loop (within-task):
- User Raw Inputs (keys, clicks)
- Interaction level
- User Responses (answer picks)
- Success/Failure events
- Feedback/Hint events
- System: Progress display state
- System: Errors logged, delays

Outer Loop (between-task):
- Task results/scores
- Resource time (adj)
- Learning gain estimates
- Success/fail/incomplete tasks
- Time on non-resources (user)
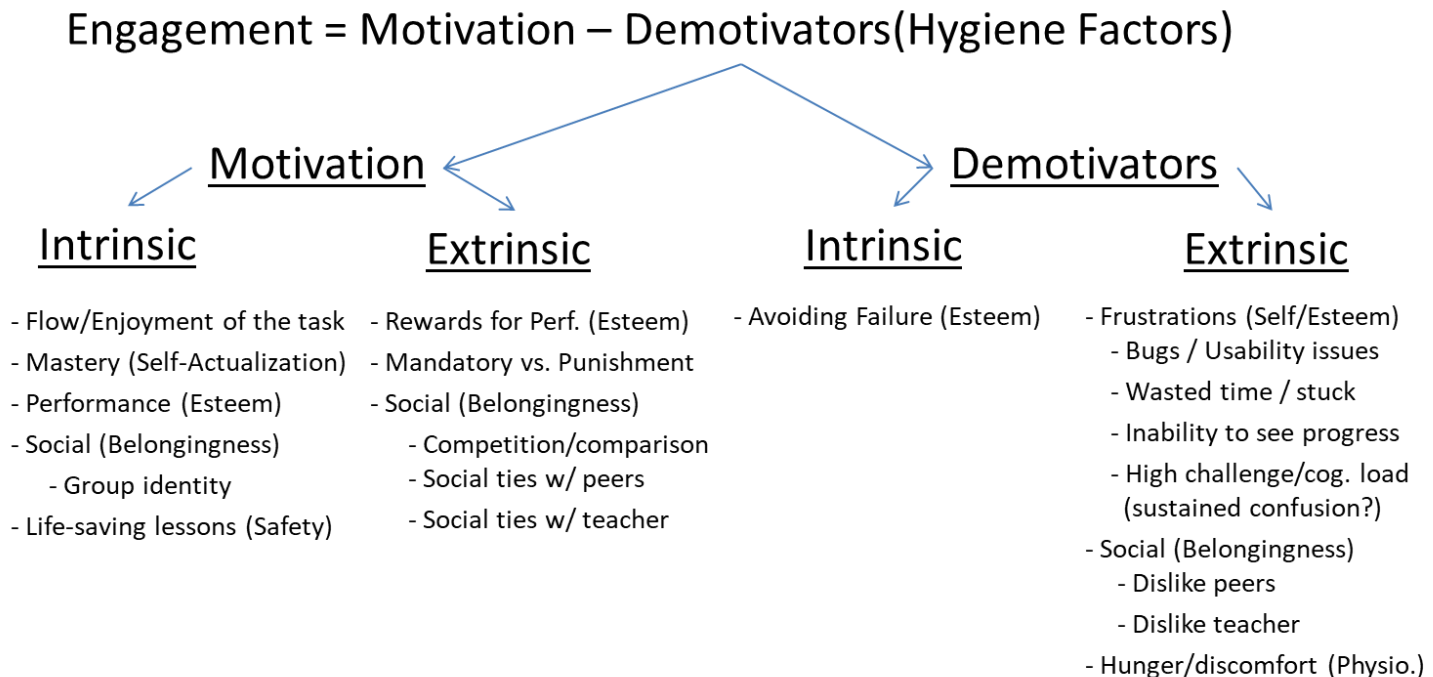- Time on non-resources (forced)

Meta Loop (between system)
- Longevity (time using)
- Activity (last login, freq use)

Self-Report (outside tasks):
- Motivations (from above-right)
- Intent to use (# hours)
- Anxiety (worry about fail)

Engagement/Motivation Models

- Synthesized model from review of research-based models of engagement and motivation

Engagement = Motivation – Demotivators(Hygiene Factors)

<u>Motivation</u>

<u>Intrinsic</u>

- Flow/Enjoyment of the task
- Mastery (Self-Actualization)
- Performance (Esteem)
- Social (Belongingness)
   - Group identity
- Life-saving lessons (Safety)

<u>Extrinsic</u>

- Rewards for Perf. (Esteem)
- Mandatory vs. Punishment
- Social (Belongingness)
   - Competition/comparison
   - Social ties w/ peers
   - Social ties w/ teacher

<u>Demotivators</u>

<u>Intrinsic</u>

- Avoiding Failure (Esteem)

<u>Extrinsic</u>

- Frustrations (Self/Esteem)
   - Bugs / Usability issues
   - Wasted time / stuck
   - Inability to see progress
   - High challenge/cog. load
     (sustained confusion?)
- Social (Belongingness)
   - Dislike peers
   - Dislike teacher
- Hunger/discomfort (Physio.)

Metrics/measures of engagement and motivation from model

- Extracted/adapted measures predicted by model
- Computationally deriving metrics from data sources
  - most recent self-report data in the database
  - existing data from previous sessions (if any)
  - intervals during session
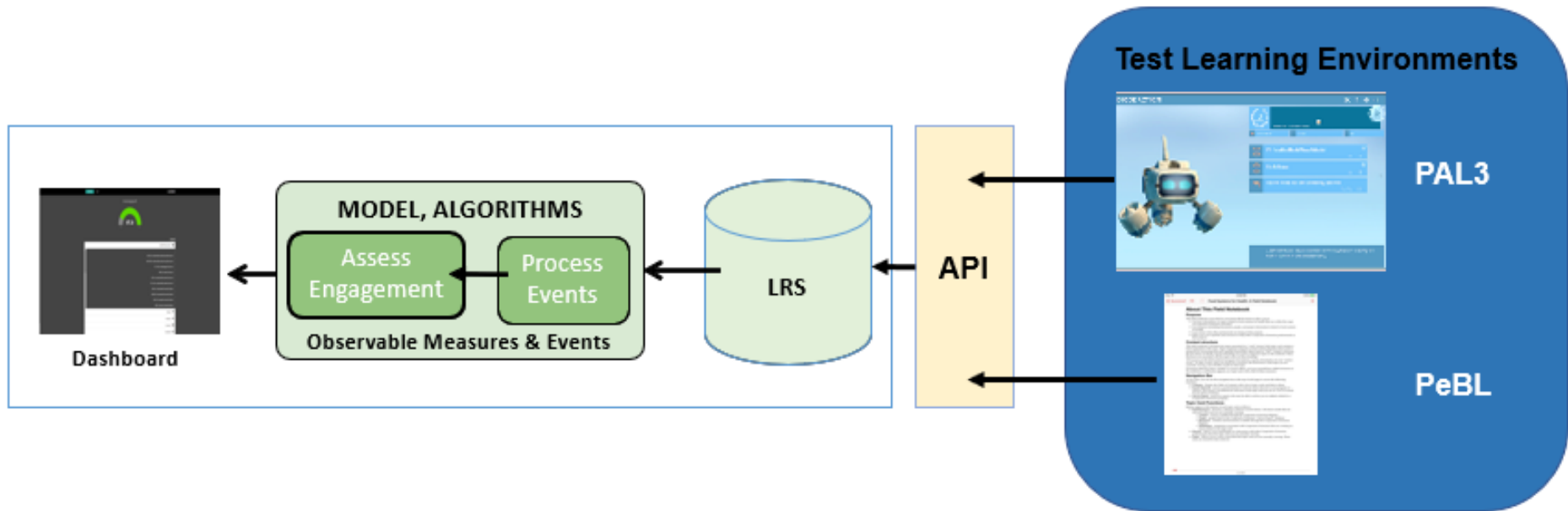 - end of each session

Example Metric Calculations

Hints_Ratio	#hints used this session / average hints used per person per session for all users
Skip_Ratio	#skips used this session / average skips used per person per session for all users
Combined_Evasion_Ratio	(Hints_Ratio + Skip Ratio)/2
Initial_Intrinsic_Motivation	8 hours * ((((Interest+Self_Reported_Mastery_Orientation + Self_Reported_Acheivement_Orientation)/3) - 0.5(Weighted_Initial_Evasion_Orientation))/5)
Initial_Extrinsic_Social	0.5*((2(Instructor_Mismatch) + Peer_Mismatch)/3))
Initial_Extrinsic_Rational	(Mandatory_Penalty_Severity + External Rewards)/2
Initial_Extrinsic_Motivation	8 hours * ((Initial_Extrinsic_Social + Initial_Extrinsic_Rational)/10)
Total_Initial_Engagement	IF (Initial_Extrinsic_Motivation >= Initial_Instrinsic_Motivation), Initial_Extrinsic_Motivation; ELSE Initial_Intrinsic_Motivation

Initial Architecture

- Extract measures

- Design adaptations

- PAL3, PeBL as exemplar learning environment

# xAPI Statements

| Login | Logged-in: User logged into the system. |
Logout	Logged-ouxt: User logged out of the system.
Achievement	Passed: User passed an assessment/quiz.
	Failed: User failed an assessment/quiz.
Completed	Completed: User completed a chapter or section of the eBook.
Return	Initialized: User opened eBook after it being shut down; started new lesson
	Interacted: User launched an eBook from the bookshelf.
Timeout	Terminated: User was disconnected from the system.
Help	Helped: User pressed a button looking for help.
Skip	Paged-jump: User skipped over pages in the eBook.
Other	Answered: User responded to an assessment.
	Paged-next: User flipped to the next page.
	Paged-prev: User flipped to the previous page.
	Commented: User highlighted text.
	Shared: User shared highlighted text with others.
	Responded: User responded to a discussion thread.
	Preferred: User acted to show more detail or hide information.
	Voided: User deleted a response or removed a highlight they made.

Proof-of-concept application of metrics using two surrogate online learning activities

- Selected PAL3, PeBL as representative learning activities
- Implemented proof-of-concept application of metrics
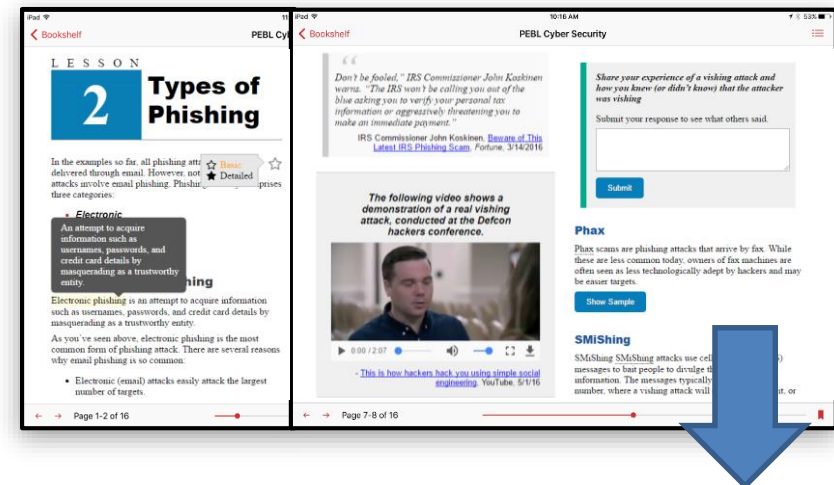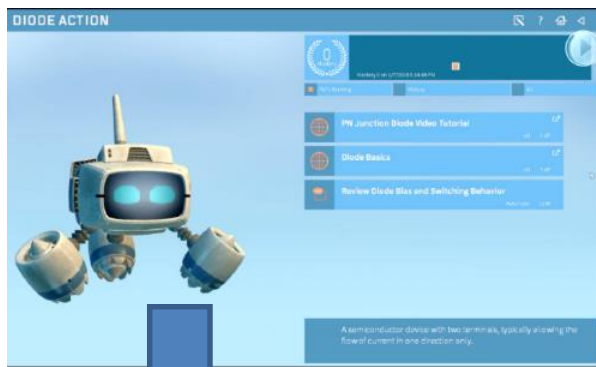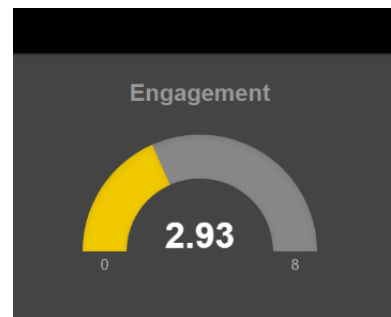
Adaptive instructional appliance

- Adopted suitable adaptive learning model based previous research, other findings
- Identified candidate set of parameters subject to adaptive control
- Identified candidate interventions & triggers for adaptive control
- Developed architectural approach for adaptive learning appliance

Next Iteration: Observational Motivation & Engagement Generalized Appliance (OMEGA)

- Implements full suite of metrics
- Incorporates adaptative interventions
- Utilizes competency-based representations
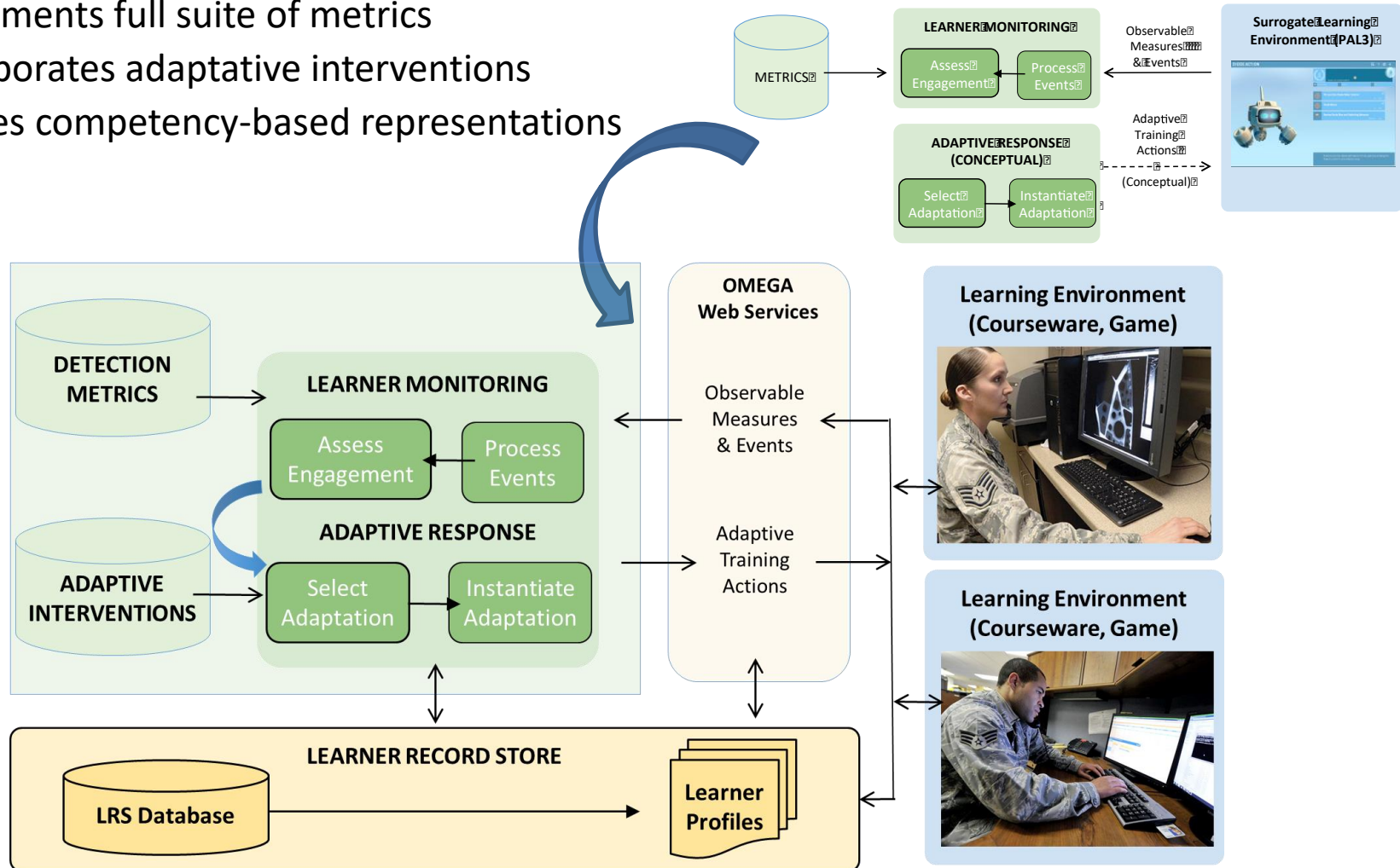
Conclusion: Improving Learning Outcomes through Adaptively Maintaining Engagement

- Approach to promoting engagement and motivation
  - Powerful suite of generalizable metrics
  - Modular adaptive learning framework
- Prototype for testing/validation of general-purpose service
  - Provides reliable measures of user engagement and motivation
  - Generates adaptive recommendations
- Generalized software appliance
  - Can be applied broadly across military and civilian training and learning enterprises
  - Adaptive training recommendations to remedy lapses in motivation/engagement