Focused authoring for building GIFT tutors in specialized domains: a case study of psychomotor skills training

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The Problem

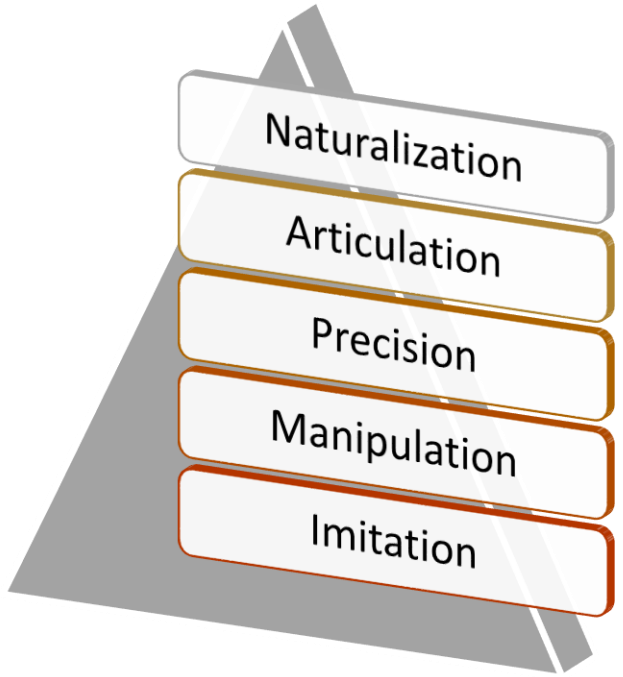
- Army's vision for 21st Century Soldier Competencies (ALM)
- Psychomotor skills foundational to full-spectrum capabilities
  - Adaptability & initiative
  - Comprehensive fitness
  - Tactical & technical competencies.
- Training is costly, limited access and tools
- Need affordable, scalable psychomotor training
- Need tool performance support for psychomotor domain and GIFT ITS authoring

Challenges of Intelligent Tutoring

- Army embracing intelligent tutoring for scalable, replicable training
  - Making Soldiers full-spectrum capable through the use of psychomotor ITS
  - Marksmanship (e.g., Goldberg, Amburn, Brawner & Westphal, 2014)
  - Tactical Combat Casualty Care (e.g., Goldberg & Cannon-Bowers, 2015).
- Still costly, time-consuming; Must be affordable, replicable, reusable process
- Solution? ITS Authoring Tools
  - Getting better but limited in scale, utility, usability, instructional value

How Are Psychomotor Skills Different?

- "Psychomotor" is not a homogenous label
  - Simpler, manual tasks (polishing boots)
  - More procedural tasks (loading artillery, performing a precision drill routine)
  - Highly complex psychomotor tasks (landing a CH-47, emergency cricothyrotomy)
- Existing frameworks include:
  - Simpson (1972) -- Seven major categories of psychomotor behaviors.
  - Harrow (1972) – Six functional categories
  - Dave (1970): Imitation; Manipulation; Precision; Articulation; and Naturalization
- Our synthesis of a taxonomy of military-relevant psychomotor skills
  - Training-relevant characteristics that influence how an authoring tool would be composed.
  - E.g. learning objectives, sequencing, instructional strategies, remediations, and assessments.



Psychomotor Domain
Based on Dave (1970)

Psychomotor Skill Acquisition

Level	Definition	Example
Observing	Active mental attending of a physical event.	The learner watches a more experienced person. Other mental activity, such as reading may be a part of the observation process.
Imitating	Attempted copying of a physical behavior.	The first steps in learning a skill. The learner is observed and given direction and feedback on performance. Movement is not automatic or smooth.
Practicing	Trying a specific physical activity over and over.	The skill is repeated over and over. The entire sequence is performed repeatedly. Movement is moving towards becoming automatic and smooth.
Adapting	Fine tuning. Making minor adjustments in the physical activity in order to perfect it.	The skill is perfected. A mentor or a coach is often needed to provide an outside perspective on how to improve or adjust as needed for the situation.

Generalized/Combined Phases of Psychomotor Domain Learning

Authoring Tool Sweet-Spot

- ITS Authoring Tools: General-Purpose/Special Purpose Tradeoffs
  - General-purpose tools provide great deal of leeway
  - Tools focused on a specific *kind* of ITS can be more powerful
- PSTAAT: Authoring tool to encapsulate knowledge to guide authoring
  - *Instructional design* knowledge tailored to iteratively teach/practice/assess skills
  - *Psychomotor Domain* knowledge for guiding design decisions and feedback
  - *GIFT ITS* knowledge for authoring, configuration, and sensor application
- Goal: AI-supported authoring for militarily-relevant psychomotor tasks
  - Embody (and help authors adhere to) assumptions about the authored product
  - Enforce rudimentary instructional principles to achieve intended outcomes
  - Provide “sidekick” and “planner” guidance with user-centered performance support
  - Streamline ITS development by leveraging templates and semi-automation

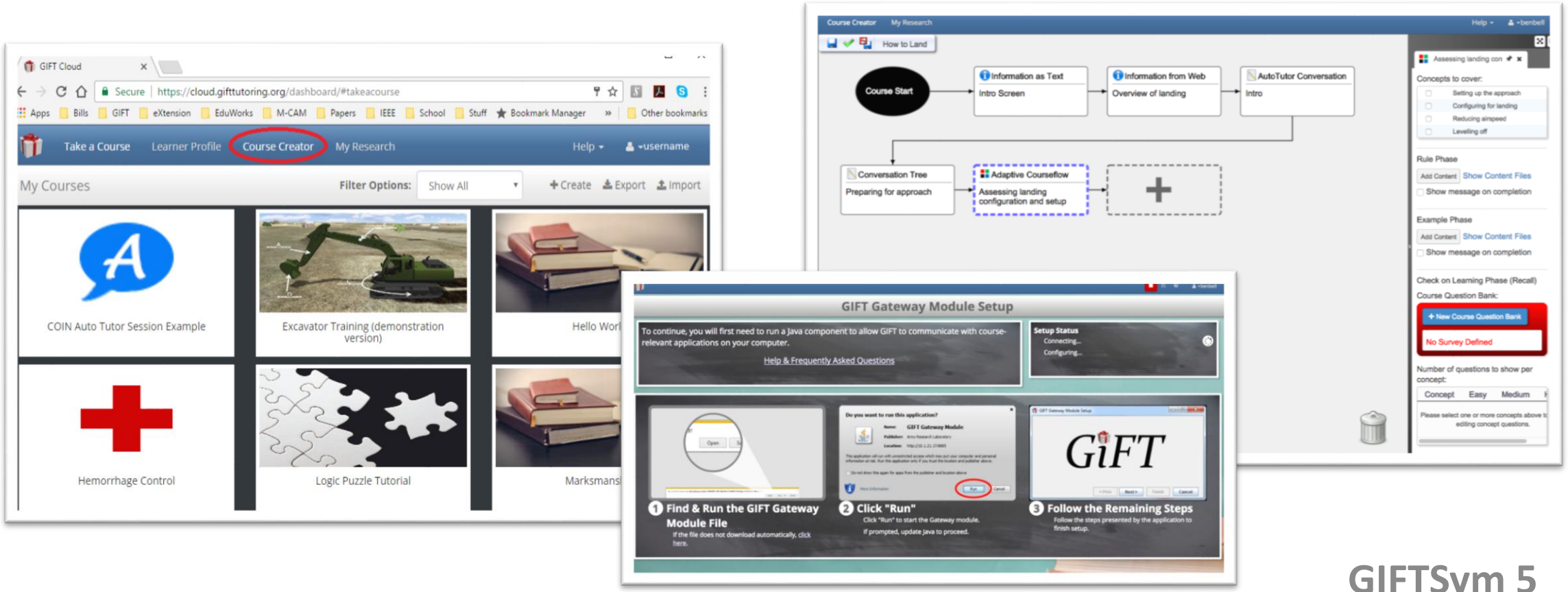
Core to Our Approach: An Exemplar ITS

- Suitable ITS Exemplar:

  Advanced Marksmanship Trainer
  - Exemplar serves as envisioned product of authoring process facilitated by PSTAAT
  - "What would a tool need to look like to have enabled the development of this ITS?"
- Benefits
  - target outcome to frame the design of the authoring tool
  - illustration for the ITS author to refer to during development
  - incrementally adapt existing ITS ("guided case adaptation" Bell, 2003)

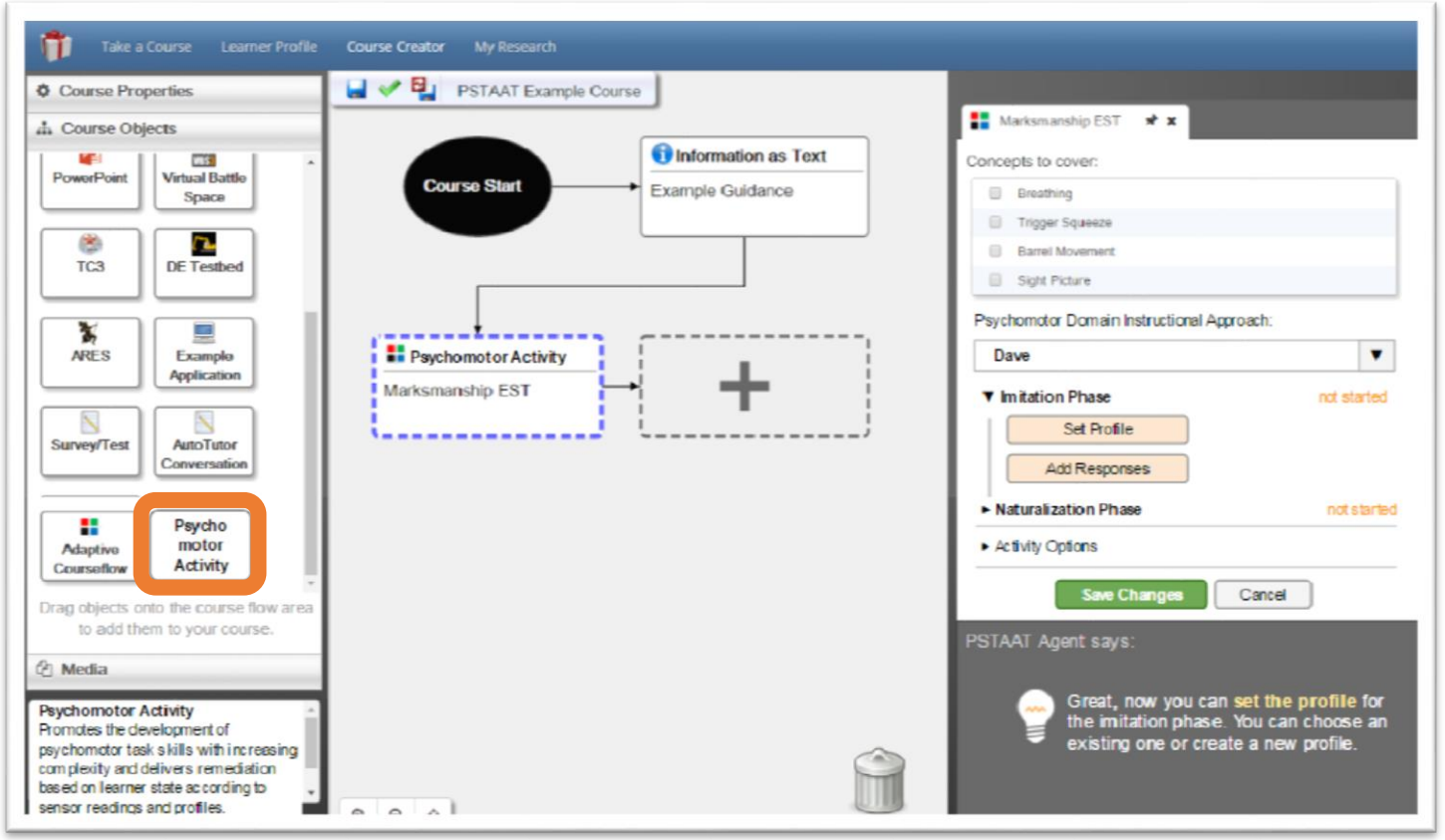
Generalized Intelligent Framework for Tutoring

- Government-owned suite of open-source ITS tools, ongoing at ARL
- Includes an authoring process with graphical interface for creating lessons



PSTAAT in GIFT

- Utilize GIFT *Course Creator*
- Create a PSTAAT *course object* to be integrated w/GIFT authoring

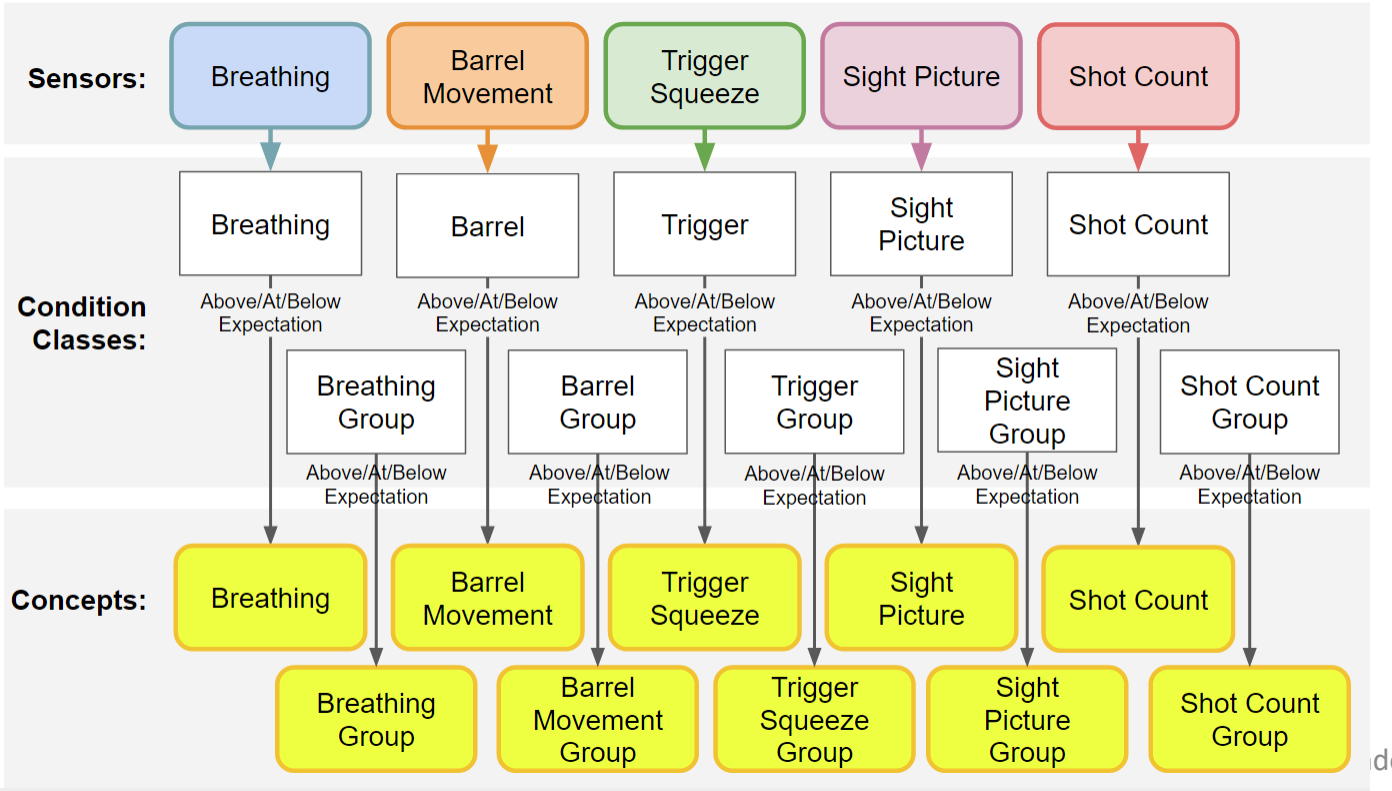


Psychomotor: Making sense of sensors

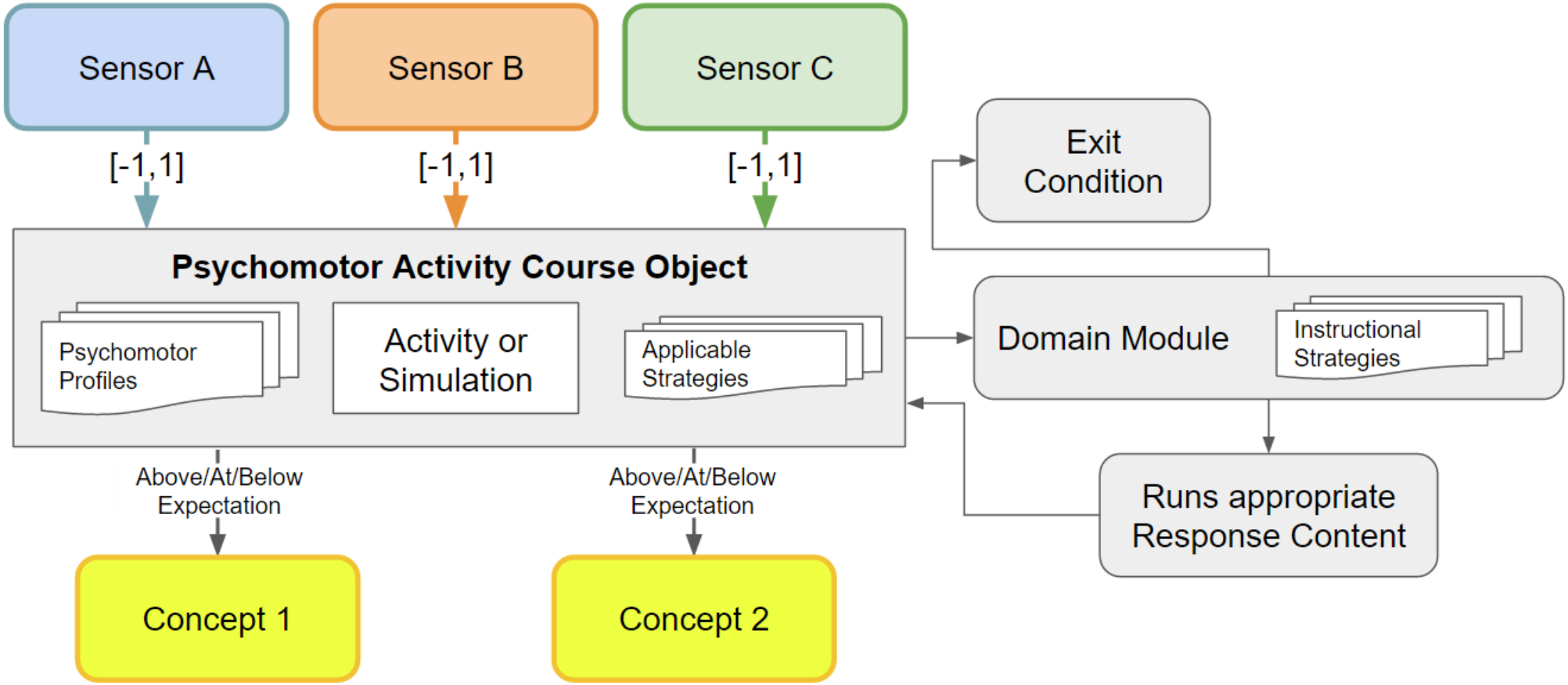
- Utilize existing and envisioned sensor devices integrated w/GIFT
  - BioHarness
  - Emotiv
  - Kinect
  - Mouse
  - Multisense
  - OS3D
  - Qsensor
  - SineWave

Psychomotor: Making sense of sensors

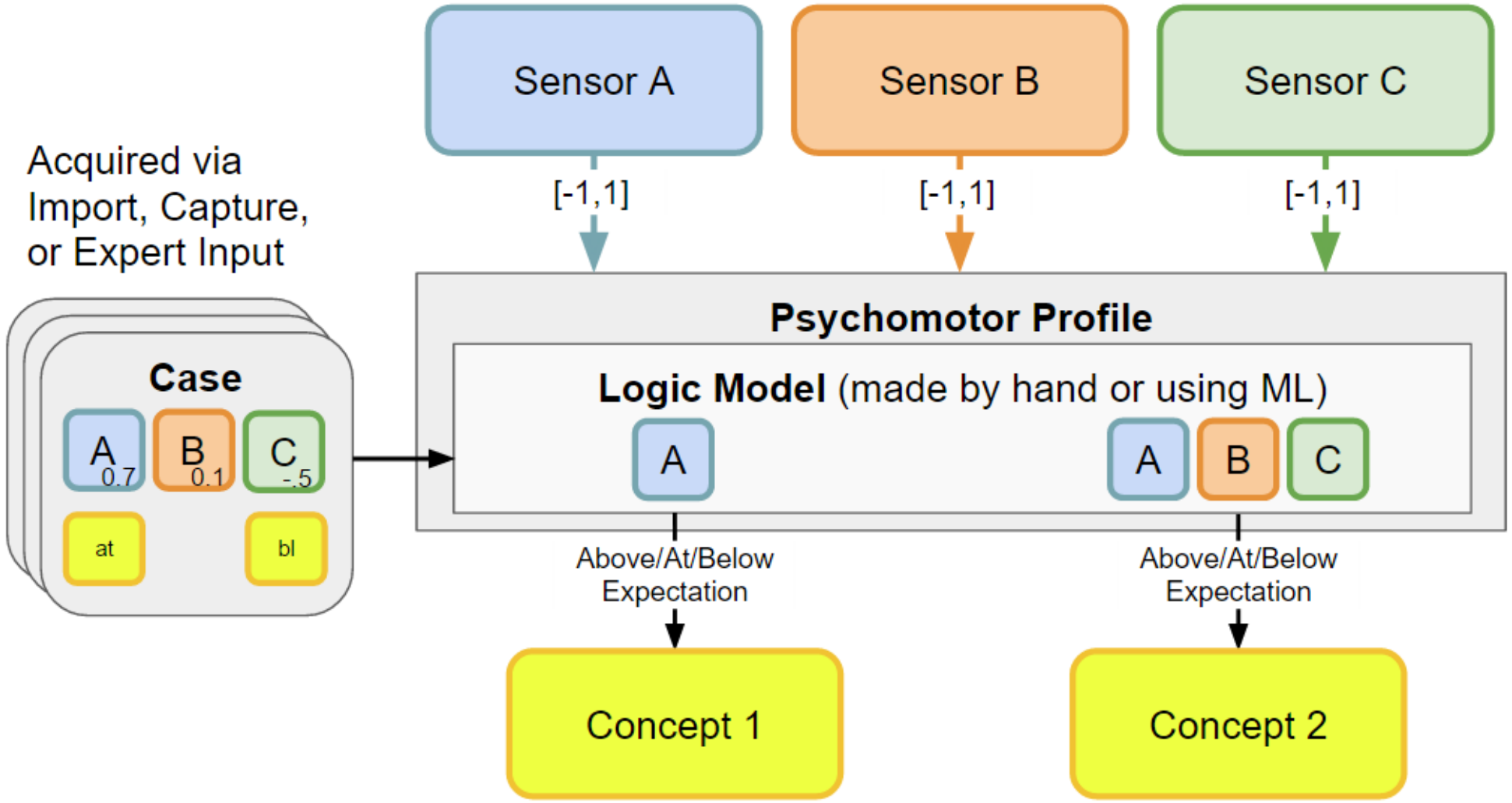
- Simplify by separating sensor configuration from instructional design
  (Psychomotor Profile) *(Psychomotor Activity)*
- Need to help author map sensors to concepts
- Generalize approach used in exemplar



Psychomotor Activity Course Object

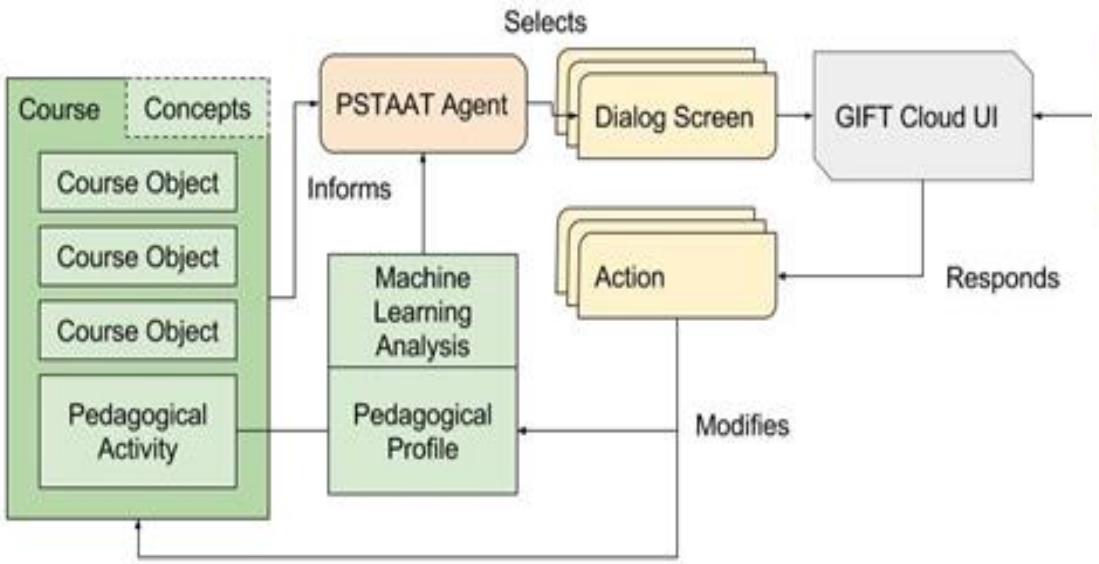


Psychomotor Profile

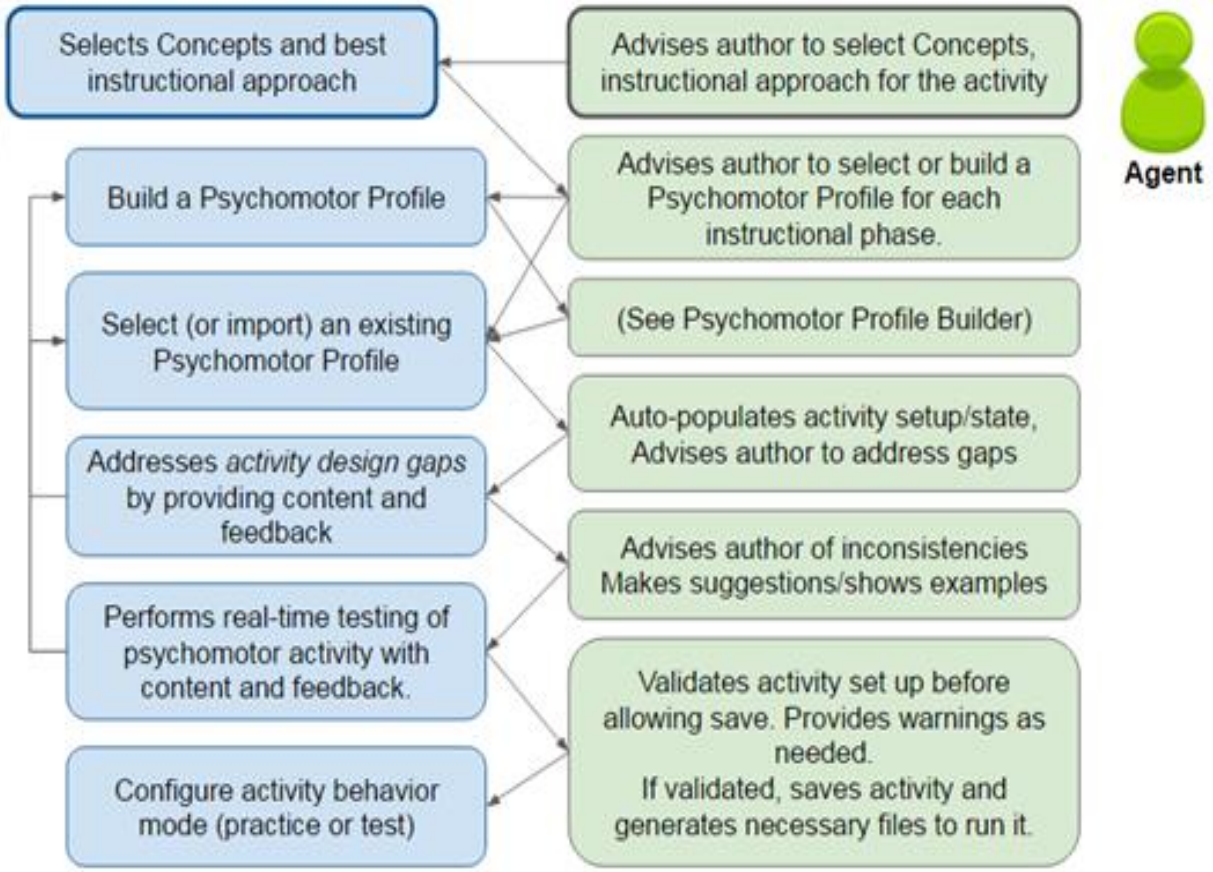


PSTAAT Authoring Agent

Functional Block Diagram

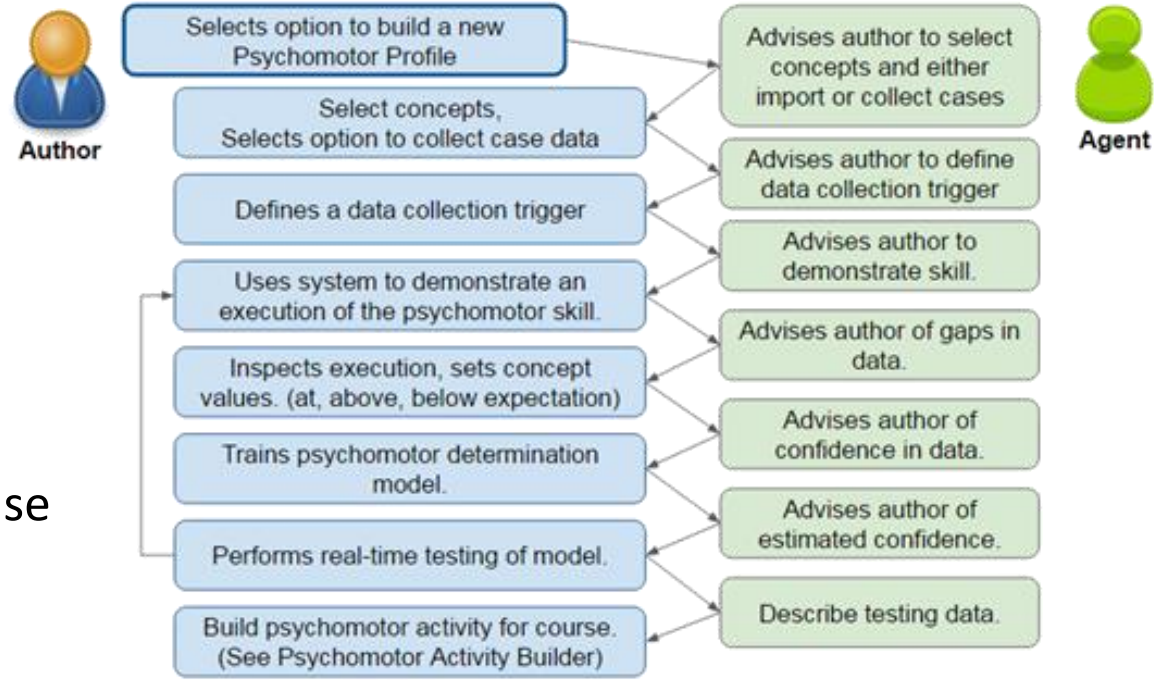


Dialogue Outline for Building Activity

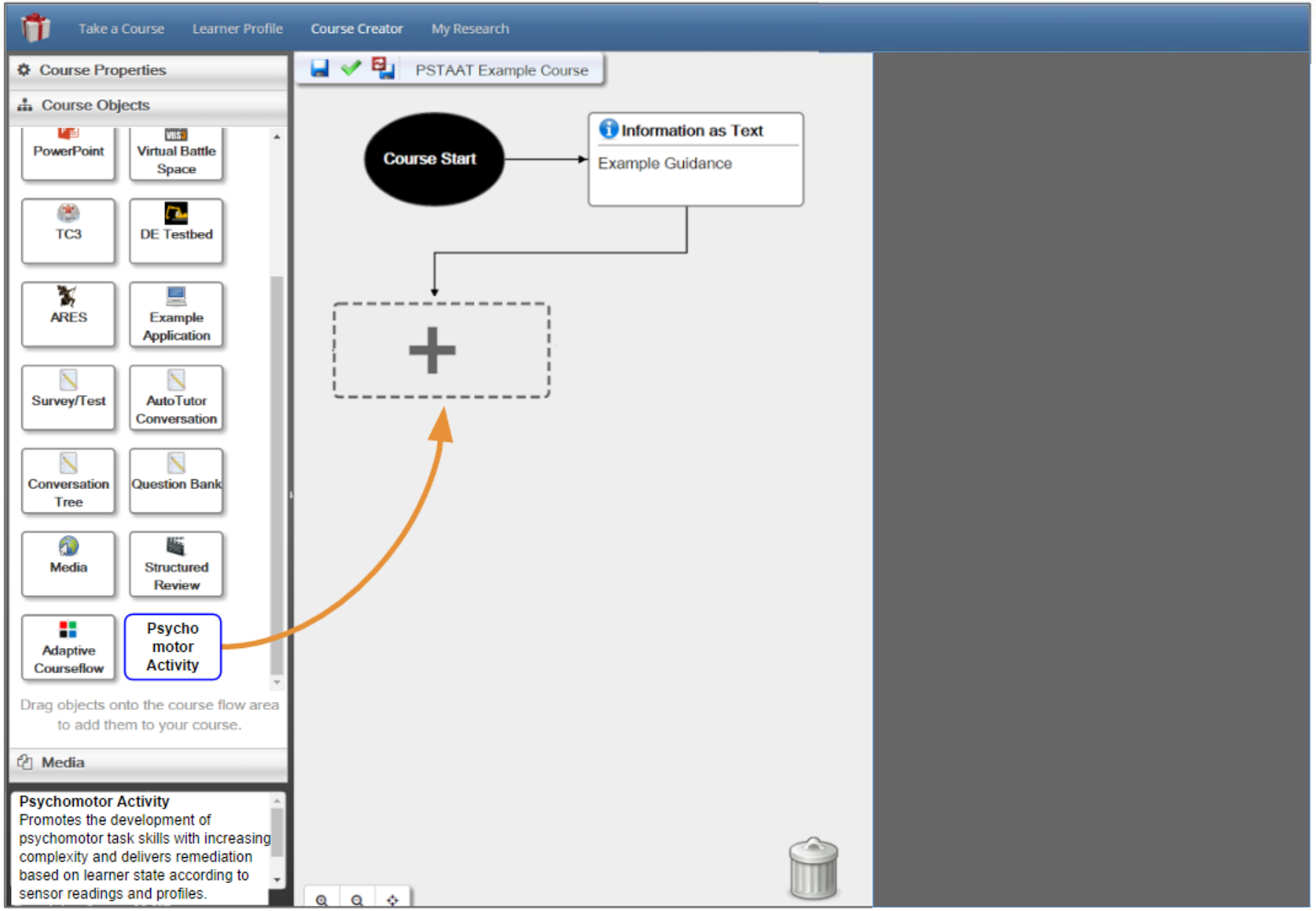


Authoring Agent w/Machine Learning

- Train ML model using demonstration cases
  - Author creates Psychomotor Profile
  - Selects and calibrates sensors
- System requests demonstration of activity
  - Author (or expert) demonstrates activity
  - At specified threshold levels (below, at, above)
  - Author accepts or rejects each demonstration case
- Repeat until ML model can recognize level
- System identifies gaps in model
- Model can correctly and completely measure performance.

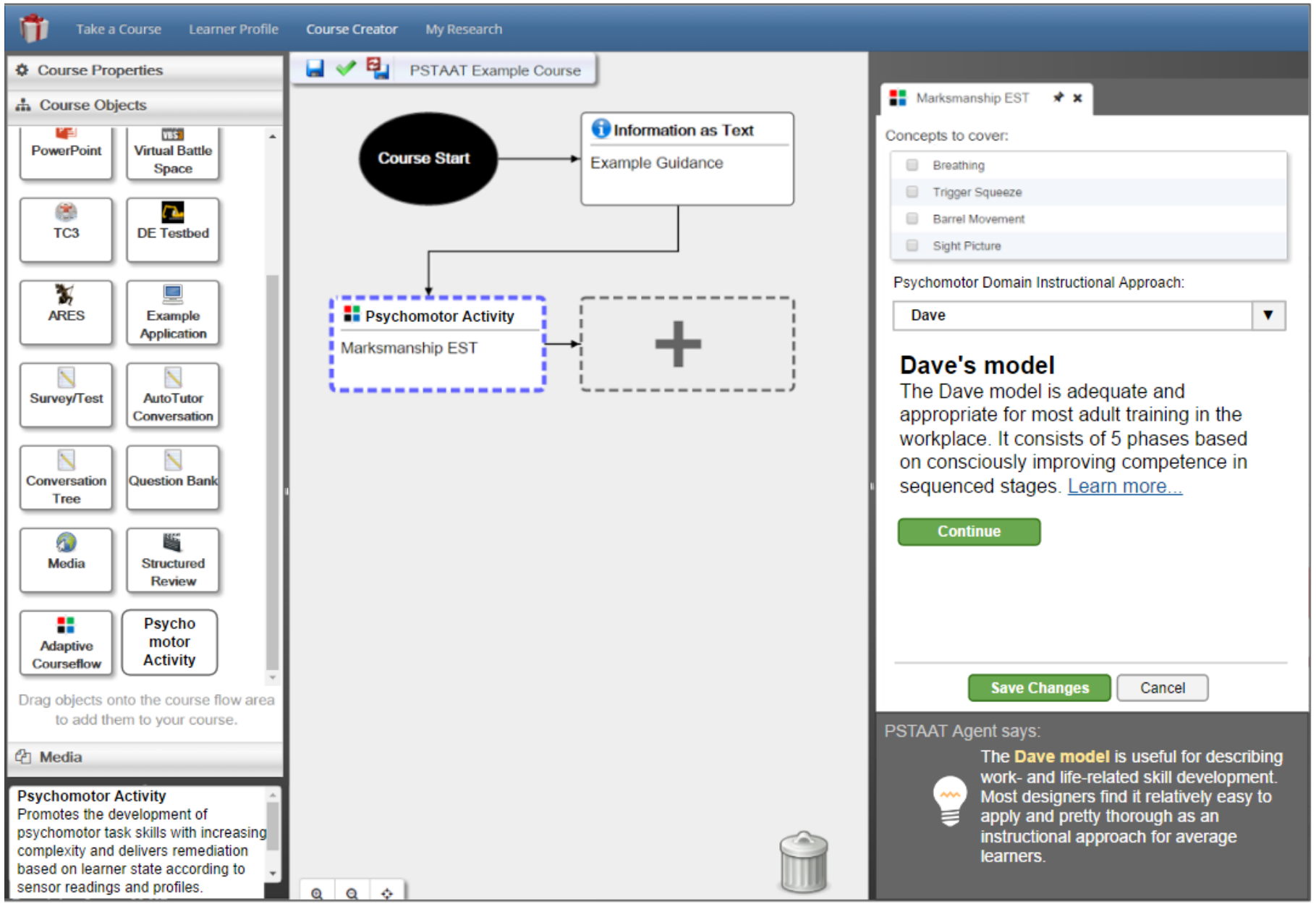


Psychomotor Activity Course Object



Author adds a *Psychomotor Activity* course object to a course.

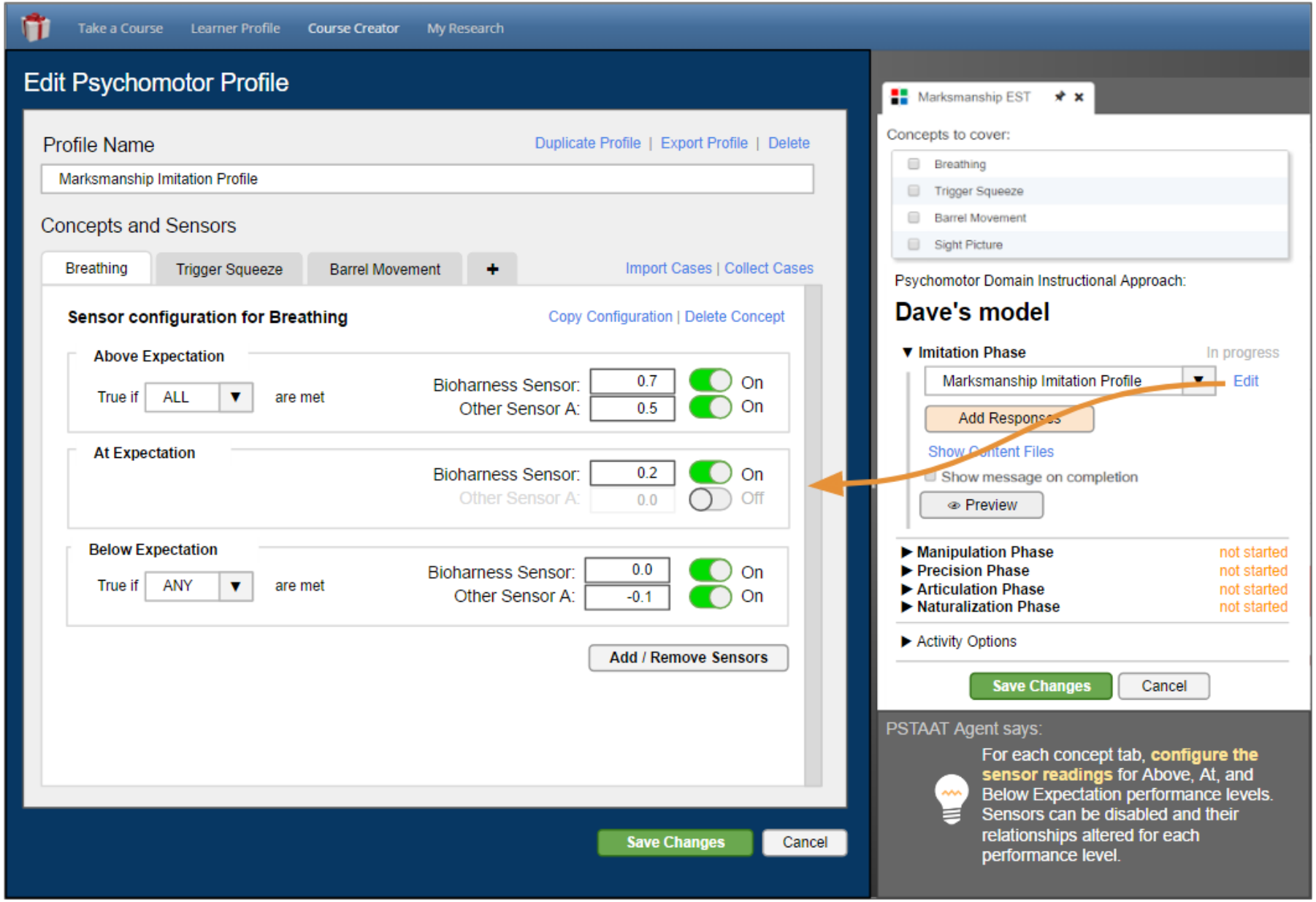
Building the Psychomotor Activity



Author selects concepts and a Psychomotor Domain Instructional Approach from list.

Agent auto-generates corresponding instructional phases and learner guidance from templates.

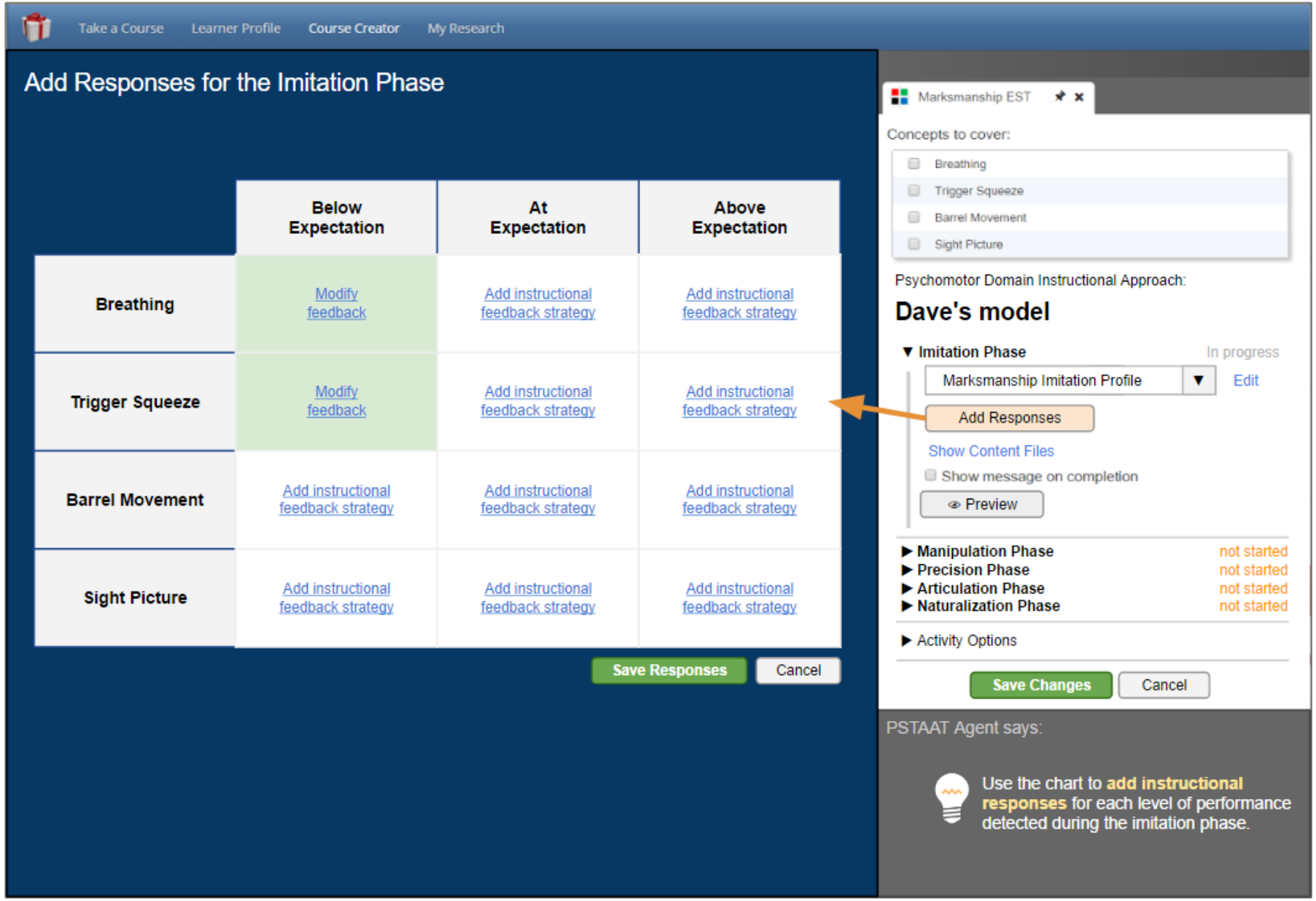
Building the Psychomotor Activity



For each phase, Author selects a Psychomotor Profile from list to reuse or edit.

Agent generates placeholder instructional strategies for all possible learner performance scenarios.

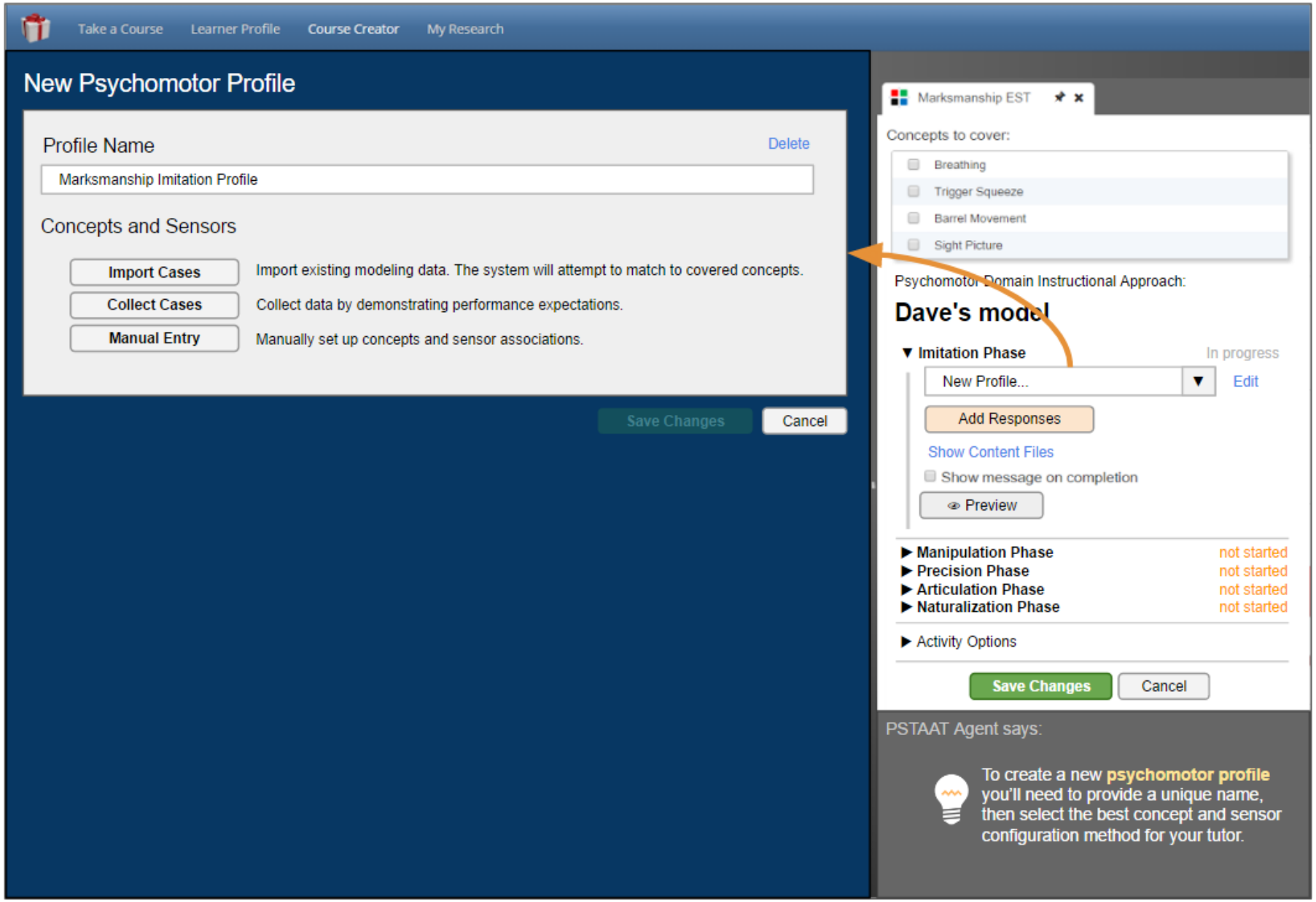
Building the Psychomotor Activity



Author designs ITS instructional strategies for each possible performance scenario.

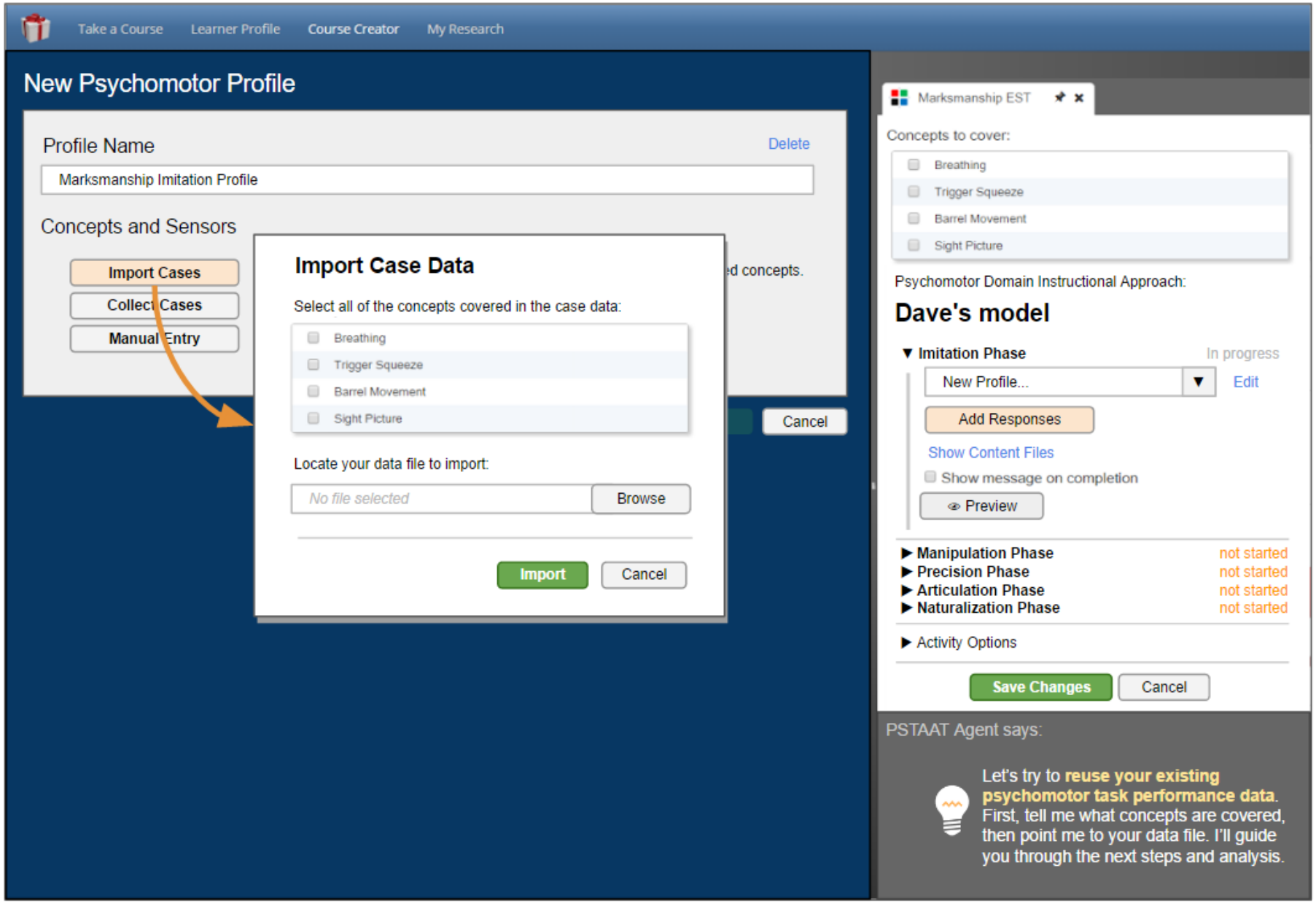
Author has option to review ITS behavior for each phase by using Preview Mode.

Building a Psychomotor Profile



Author can create a new Psychomotor Profile by selecting "New Profile..."

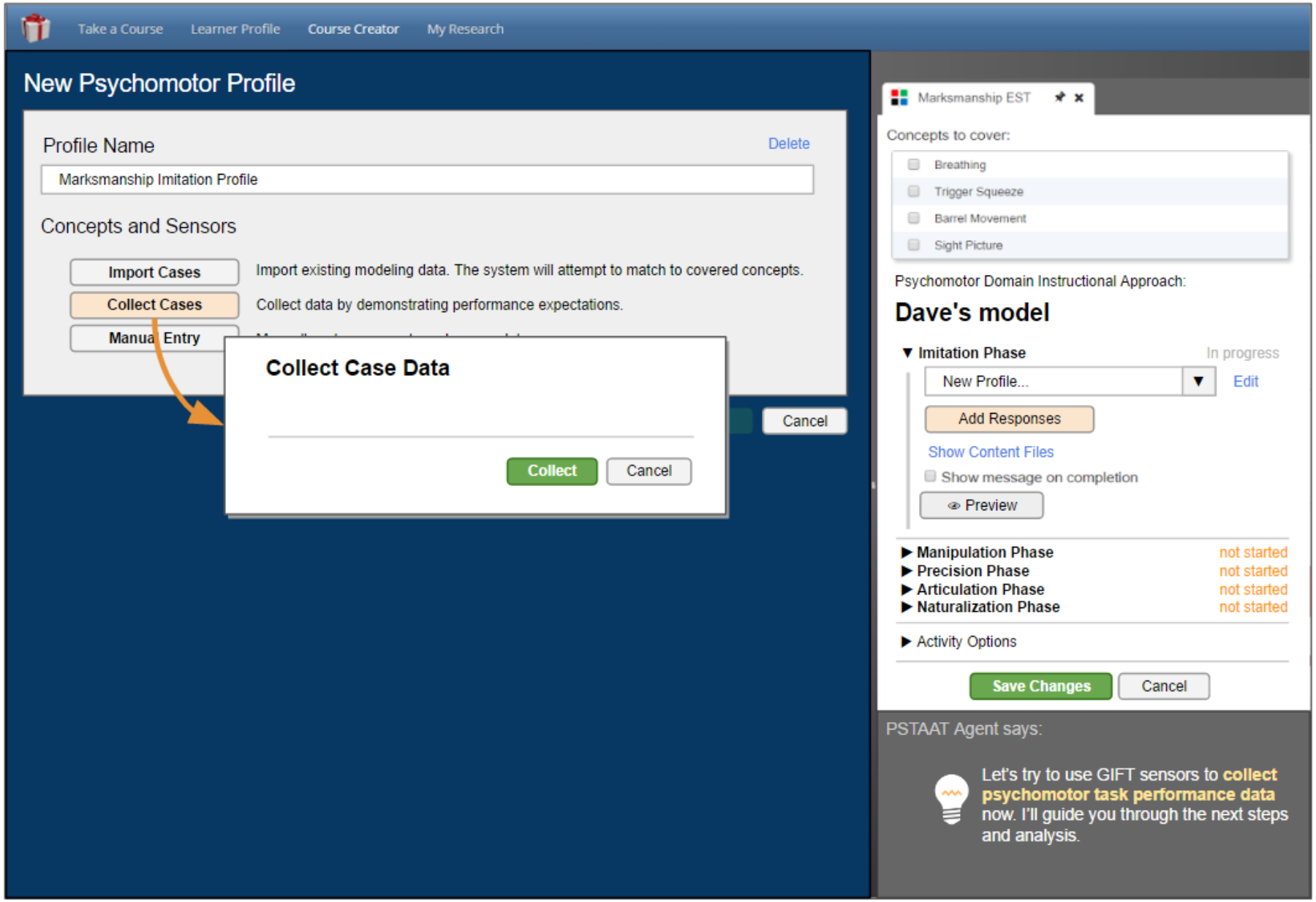
Building a Psychomotor Profile



Author has option to import existing sensor/performance data.

Agent analyzes the imported data and uses ML techniques to recommend sensor performance level thresholds.

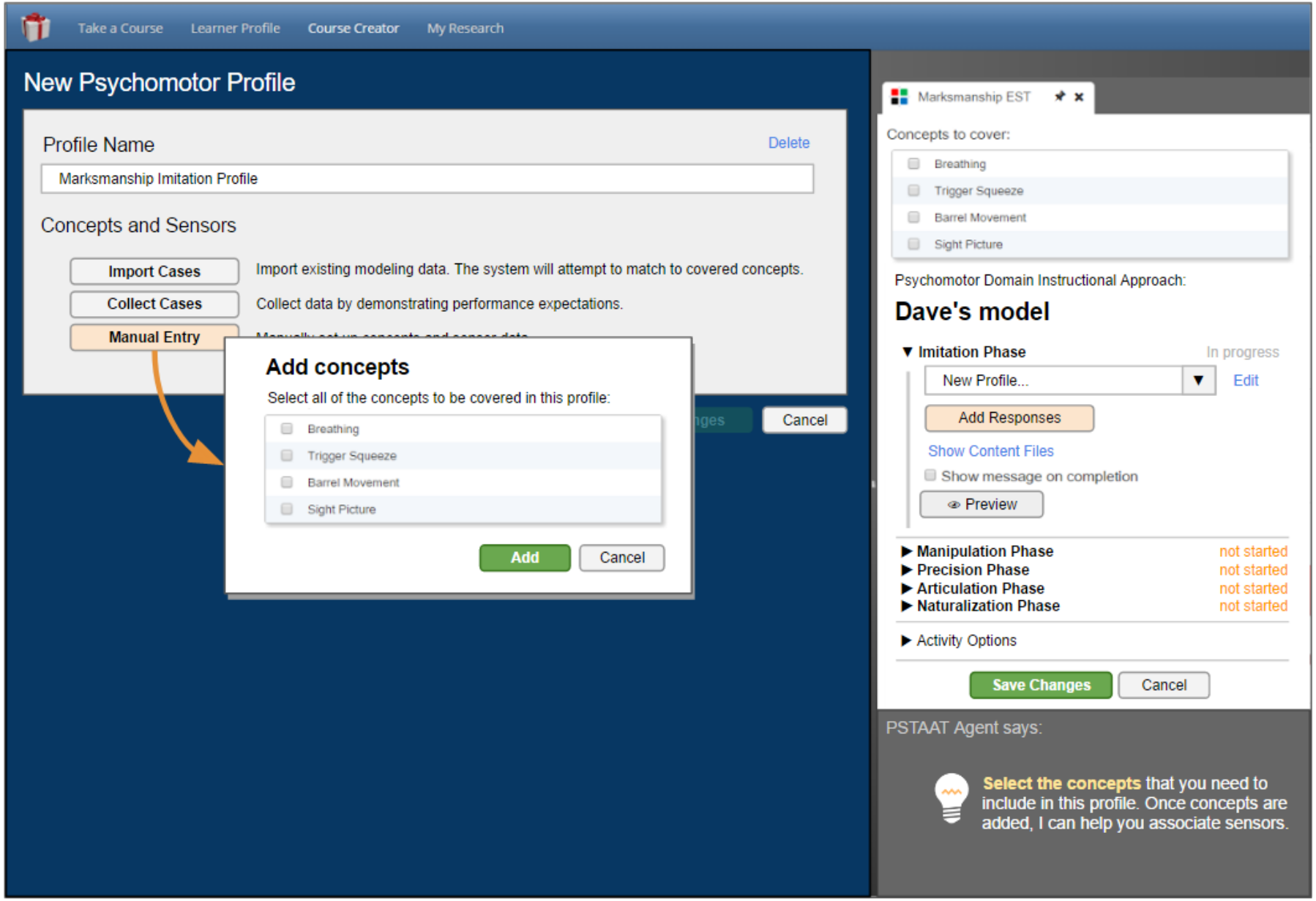
Building a Psychomotor Profile



Author has option to collect sensor/performance data.

Agent launches ML-supported process using GIFT as experiment station to measure and collect performance demonstration cases.

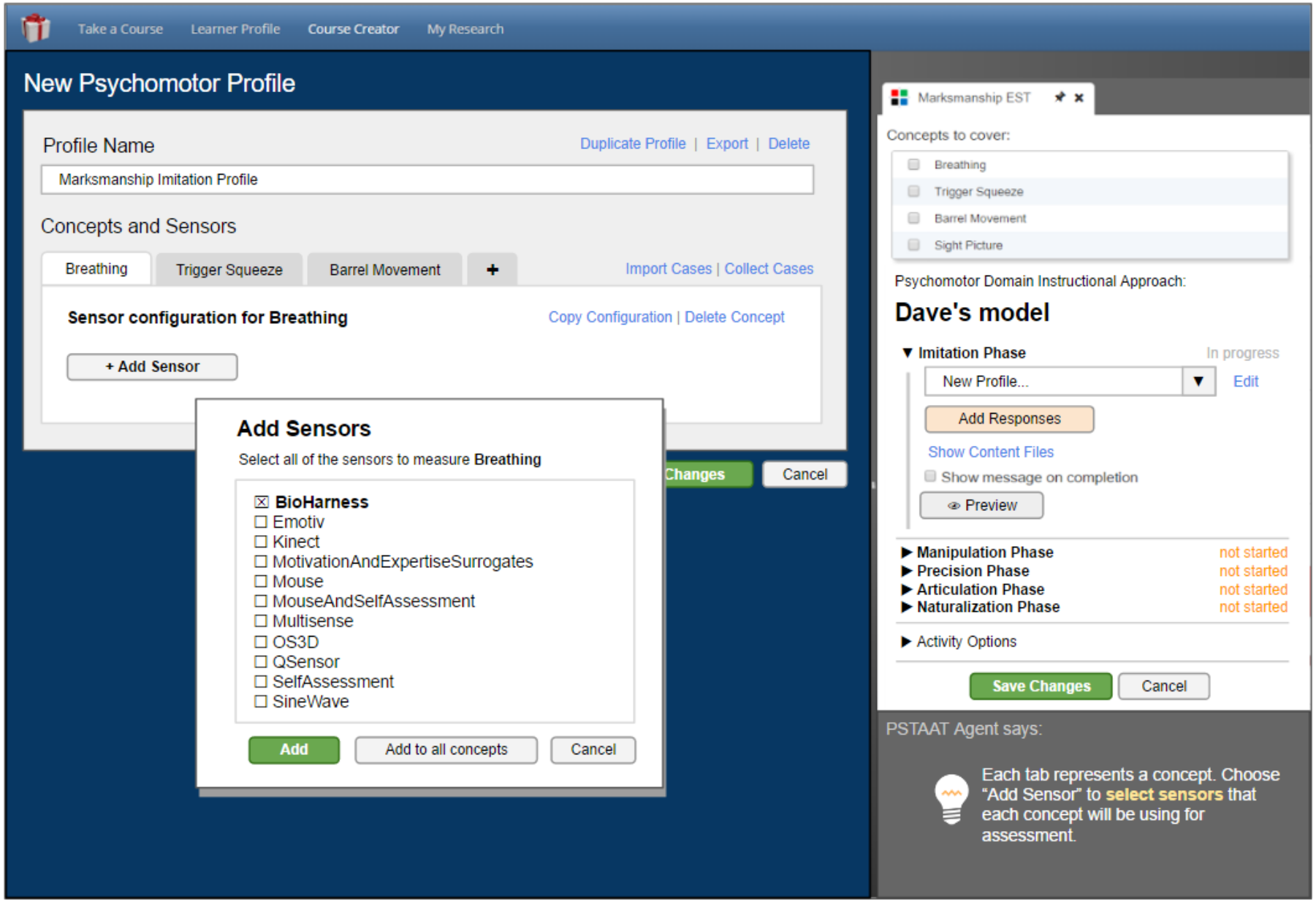
Building a Psychomotor Profile



Author has option to create a profile manually in an agent-guided process.

Author starts by adding concepts to be covered in the profile.

Building a Psychomotor Profile

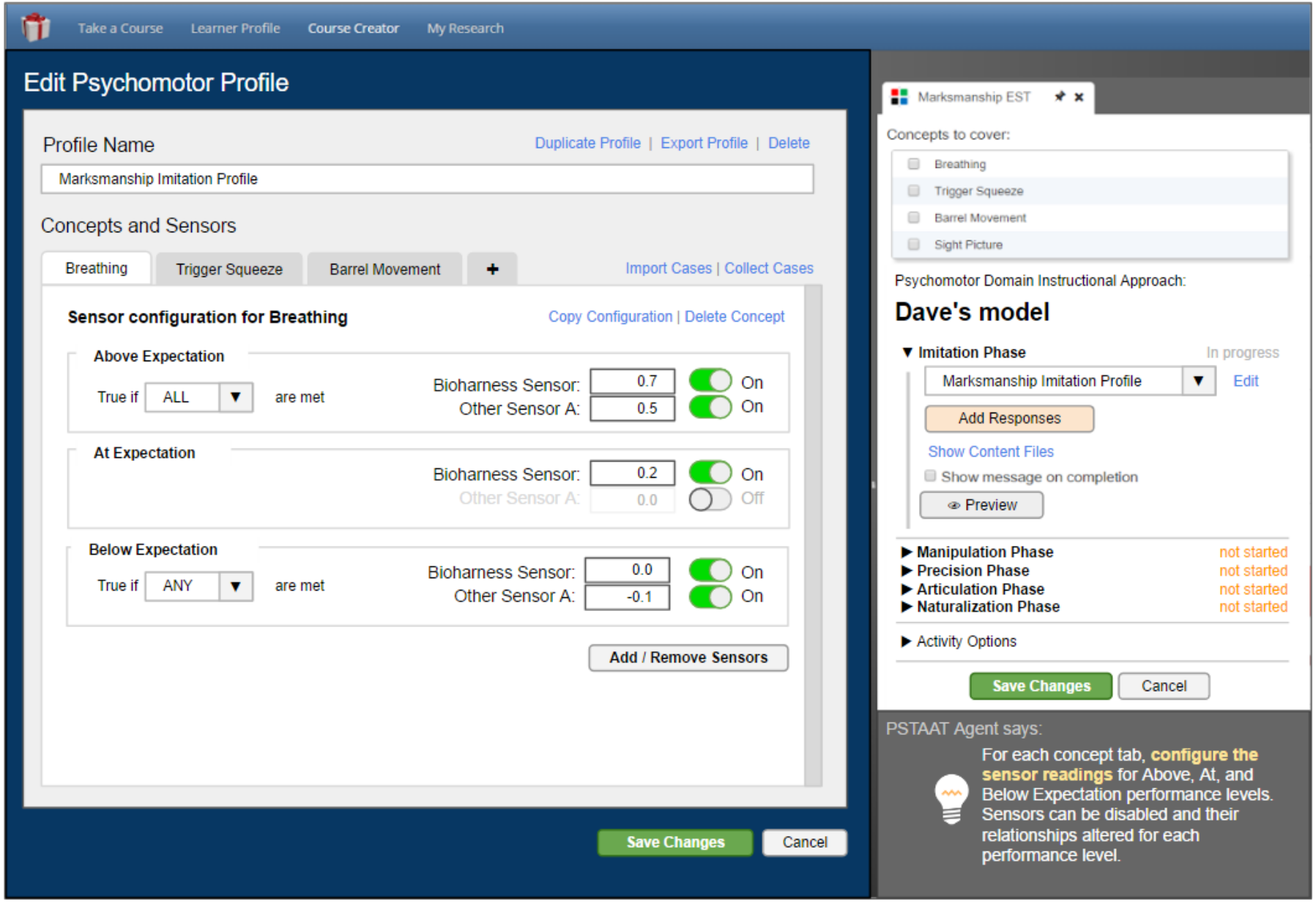


Agent generates tabs per concept.

Author can add more concepts with "+" tab.

Author adds sensor(s) used to measure performance in each concept tab.

Building a Psychomotor Profile



Agent incorporates selected sensor(s) in the concept tab(s).

Author enters sensor thresholds for Above, At, and Below Expectation levels of performance.

Sensors can be disabled, added, removed, combined.

PSTAAT Summary

- GIFT, other authoring tools can streamline sim-based ITS development
  - Help Army achieve its ALM objectives; more broadly for force-wide readiness
  - Limitations of general-purpose tools addressable w/specialized instances of tools

- PSTAAT provides specialized authoring within GIFT authoring framework
  - Focusing on specific categories of skills can give tools more knowledge & power
  - Agent-guided workflow, decision support, and contextual examples provide powerful aid
  - Streamlines ITS development with templates, reuse, semi-automation
  - Supports development of simulation-based ITS in the psychomotor domain.
  - Demonstrates use of exemplar ITS as basis for creating new instances

- Can support diversity of psychomotor skills ITS authoring
  - Templated approach provides path for extensions and customizations

Moving forward

- PSTAAT templates, imports, and exports
  - Authoring agent uses JSON templates to define concepts, instructional approaches, and task workflows
  - PSTAAT tool imports/exports psychomotor profiles, psychomotor activities, *instructional strategies
  - Is this (or similar) templated approach of general interest to other GIFT tools?
- PSTAAT ML-supported features
  - Existing GIFT psychomotor task performance data sources
- Leveraging existing/future GIFT components
  - Reuse is good – harmonization is key
  - Can we embed existing course objects in a psychomotor activity's instructional strategies?
  - Would like more visibility of GIFT Cloud roadmap, related components