OntarioTech Engineering & Applied Science

ARiSE LAB

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Towards VAD-Based Emotional Reasoning in the Goal-Oriented Requirements Language

From Traditional Requirements to Human-Centric Requirements

Functional Requirements

what the system should do

- Desired system behaviors
- Services to be delivered
- Tasks that satisfy goals

Non-Functional Requirements

How well the system should perform

- Desired system qualities
- Safety, security, usability
- Compare design alternatives

Human-Centric Requirements

How the system should support people

- Human needs and experiences
- fairness/justice
- Bias-aware support
- **Emotional Needs**

Emotional Requirement

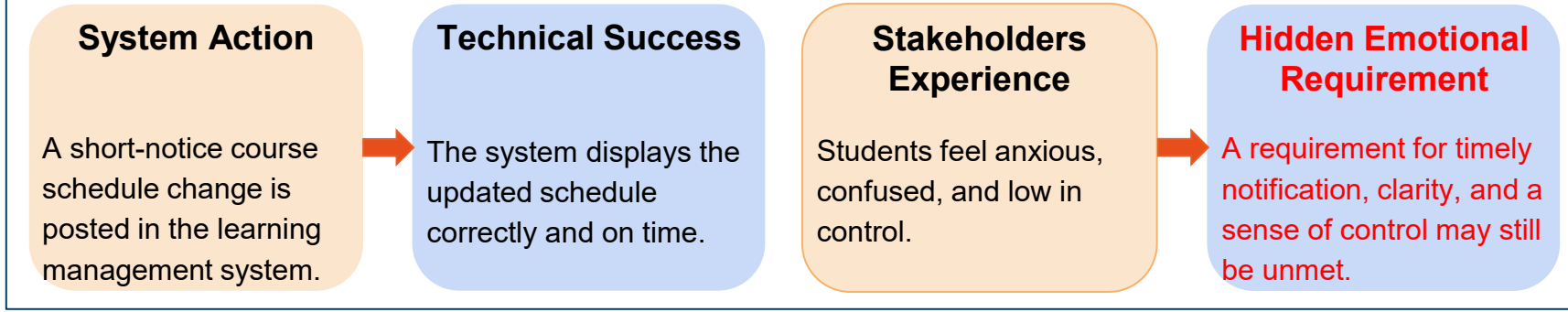
Capture users' perceptions, feelings, and emotions arising from their experience with the system. It describes intended user feelings.

Eg. Feel in control

Why Emotional Requirements Matter

Learning Management System Example

An instructor posts a short-notice change to the course schedule



FR (post the schedule change) and NFRs (correctly and on time) can explain whether the system works technically, but they do not fully capture whether students feel informed and in control.

A system can be technically correct but emotionally harmful or incomplete.

Key Gaps in Emotional Requirements Modeling

Existing approaches acknowledge emotions, but provide limited support for incorporating them into goal-oriented requirements analysis.

Elicitation Gap

Emotional feedback is often collected without a structured process for deriving emotional requirements.

Quantification Gap

Subjective emotional states are difficult to transform into measurable and analyzable values.

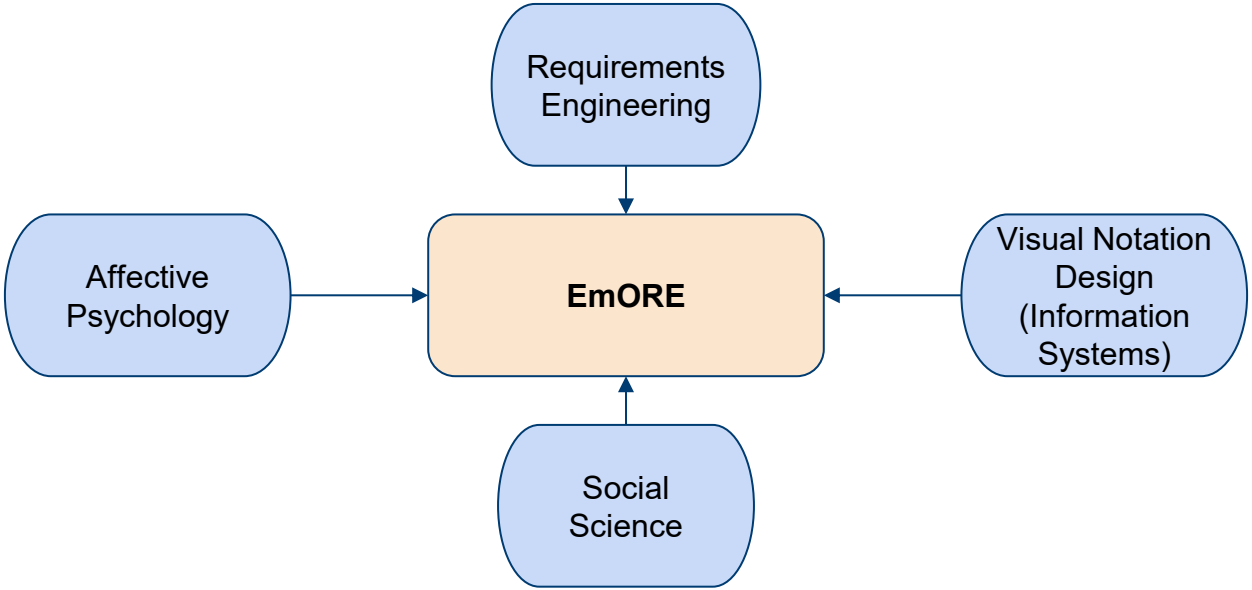
Representation Gap

Goal models lack explicit constructs for representing emotional states and desired emotional outcomes.

Research need: A structured approach to **elicit**, **quantify**, and **represent** emotional requirements in GRL.

Proposed Solution: EmORE

EmORE is an approach for incorporating emotional information into Requirements Engineering by systematically collecting emotional feedback and extending GRL to represent emotional requirements.



Valence–Arousal–Dominance (VAD) Model Makes Emotions Measurable

A dimensional emotion model from affective psychology: emotions are represented through Valence, Arousal, and Dominance.

Where it comes from

Field
Affective psychology
Core idea
Measure emotional states along continuous dimensions and reduce ambiguity in discrete emotion labels
Why EmORE uses it
The values can be aggregated and used to analysis
Measurement method
5-point Likert-type rating scale

What is it

Valence: Emotional Pleasantness
Measures how negative or positive an emotional experience is
Arousal: Emotional Activation
Measures the level of emotional energy, intensity, or activation
Dominance: Perceived Control
Measures how much control or influence a person feels in a situation

How the 1–5 VAD scale is interpreted

Score	Valence	Arousal	Dominance
1	Very negative	Very relaxed	Very low control
2	Negative	Relaxed	Low control
3	Neutral	Neutral	Balanced control
4	Positive	Tense	High control
5	Very positive	Very tense	Very high control

Scenario-Based Emotional feedback Questionnaire Template

A. Example of VAD Emotional State Guide Provided to Participants

(Before the assessment, participants are provided with a detailed explanation of the survey itself and the information about the Valence, Arousal, and Dominance dimensions.)

Eg, This survey aims to explore how students perceive and express emotions in practical academic scenarios. For each emotion word you provide, please rate it using all three dimensions: Valence, Arousal, and Dominance. Please review the definitions of these dimensions before answering the questions.

Valence Level	Explanation	Corresponding Word
1-Very Negative	Strong, completely unhappy.Expresses strong dissatisfaction, anger, disappointment, or disgust.	annoyed,frustrated,miserable...
2-Negative	General unhappy.Expresses mild dissatisfaction, minor issues, or the need for improvement, but not extreme anger	bored,disappointed,uneasy...
3-Netural	Neither happy nor sad.Typically objective statements of fact, questions, or lack of strong emotional expression	neutral,balanced,grounded...
4-Positive	General happy.Expresses intermediate feelings of pleasure	glad,relieved,cheerful...
5-Very Positive	Strong, extreme happy. Expresses excitement, high satisfaction, profound praise, or love	happy,pleased,satisfied...

B. Scenario-experience Question (Repeated for each scenario)

(Scenarios should describe realistic and emotionally relevant interaction situations that stakeholders may encounter while using the system. Each scenario should focus on a specific issue or experience that may influence stakeholders' emotional states and should be written in a clear, concise, and context-aware manner. The scenario should also be traceable to one or more related GRL model elements.)

Scenario Example

While checking your grades in the course system, you notice a score item that was not previously introduced or explained. The meaning of this item and how it was evaluated are unclear. ( )

Have you personally experienced this situation ?

YES ⇨ proceed to the emotion assessment section

No ⇨ skip the emotion assessment and continue to the next scenario

C. Emotion Assessment Form

Part 1 -Provide one emotion word that best describes how you feel in this scenario.

Part 2 - Rate the emotion word you provided on each of the following dimensions: Valence, Arousal, and Dominance.

Valence(Very Negative↔ Very Positive)	1	2	3	4	5
Arousal(Very Relaxed ↔ Very Tense)	1	2	3	4	5
Dominance(Very low Control ↔ Very High Control)	1	2	3	4	5

The Valence guide is shown as an example; the full template also includes Arousal and Dominance guidance.

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From Raw Emotion to Model-Ready Data

The analysis pipeline reduces noise and prepares data for EmORE-GRL modeling.

Outcome: emotional information becomes structured enough to support visual modeling and traceability.

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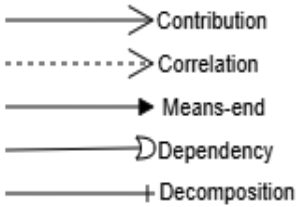
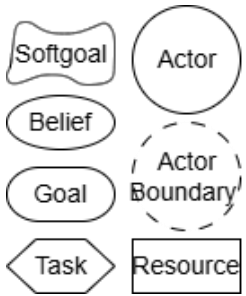
Begins with Goal-Oriented Requirements Language (GRL)

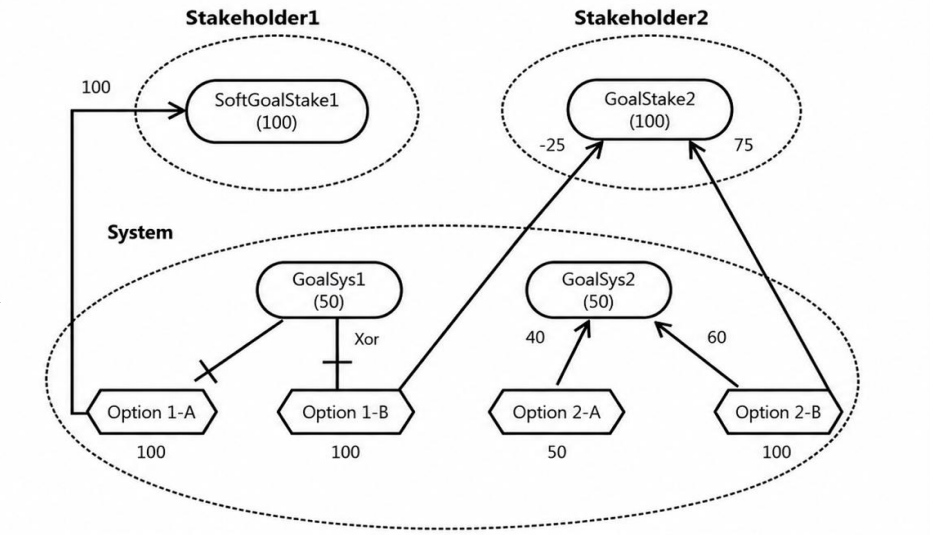
GRL already models goals, tasks, softgoals, actors, and relationships - but not emotions explicitly.

Relationships



Intentional Elements





Stakeholder & boundaries: who is involved
Goals & alternatives: what they want/how to achieve it
Relationships: how elements support or depend on each other

What is missing in standard GRL

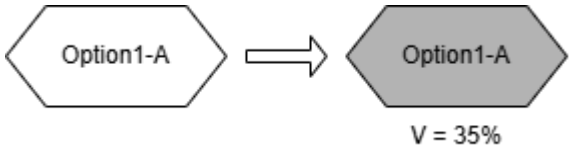
Emotional States	Emotional Goals	VAD Gap
No dedicated construct for stakeholder feelings such as anxiety or confusion.	No clear way to represent desired outcomes such as reassurance or control.	No visual mechanism to compare current emotional feedback with desired emotional states.

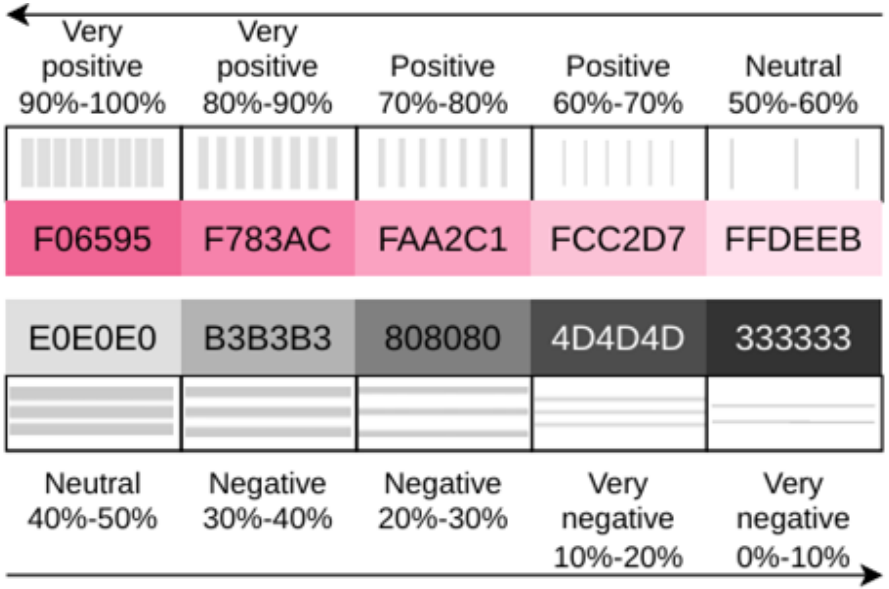
Sets on Valence Visualization Layer

Purpose

- Provides a rapid overview of which GRL elements are associated with positive, neutral, or negative stakeholder experience.
- Supports emotional triage before detailed VAD reasoning.

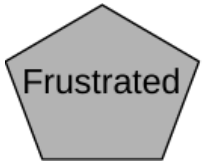
How It Works





EmORE-GRL Extension: New Constructs

High-Frequency Emotion

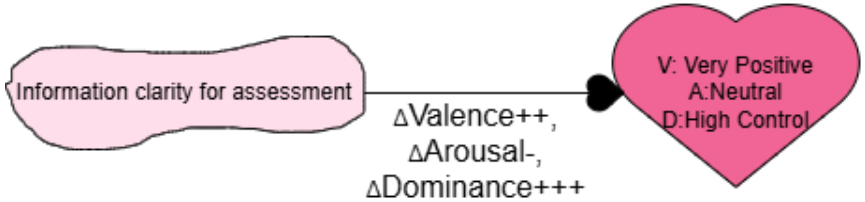


Represents an emotion word frequently reported by stakeholders for a specific system element or scenario.

Emotional Goal

Represents the desired emotional state that the system should help stakeholders achieve.

EmORE Link



Connects a GRL element to an Emotional Goal and displays the VAD gap between the current and desired emotional states.

Why This Extension is Designed This Way

PoN [1] Physics of Notations	PRISE [2] Process to Support iStar Extensions
A theory originated from the Information Systems (Visual Notation Design) to provide principles for designing cognitively effective graphical notations.	A methodology for systematically extending goal-oriented modeling languages.
❖ Checks visual/cognitive quality of a notation ❖ Emphasizes clarity, discriminability, transparency, graphic economy ❖ Helps ensure the new symbols are understandable	❖ Uses the **GRL-specific PRISE [3]** by Alwidian ❖ Provides process guidance for extending goal-modeling languages ❖ GRL-specific adaptation supports need analysis, concept design, validation, iteration ❖ Helps preserve compatibility with the host language

Result: visual expressiveness without sacrificing readability or GRL compatibility.

[1] Moody, “The Physics of Notations,” IEEE TSE, 2009.
[2] Gonçalves et al., “PRISE: A Process to Support iStar Extensions,” JSS, 2020.
[3] Alwidian, “Towards Extending GRL with Emotion-Oriented Goals,” SAM 2022.

Case Study Setup: Canvas as the Demonstration Context

Background

Domain

Canvas LMS in a University Learning Environment Scenarios, primarily grounded in SOFE 2720U: Principles of Software and Requirements Engineering, at Ontario Tech University, with additional graduate level engineering participants.

Study Context

Semester-long observation as a teaching assistant throughout SOFE 2720U, focused on Canvas use across all course activities.

Data

55 participant responses obtained

50 valid responses filtered through

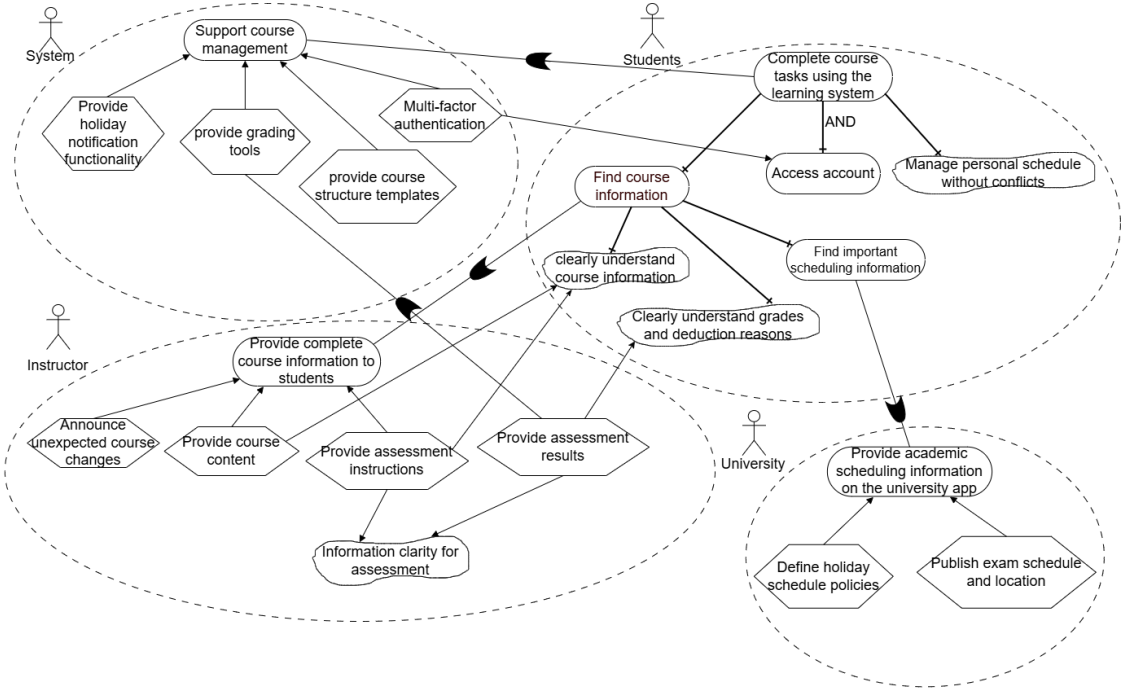
8 scenario-based questionnaire items

Emotion words + 1–5 scale VAD ratings

Scenario examples

- Missing task instructions
- Unclear holiday arrangements
- Short-notice schedule change
- Unexplained score items
- Grades without feedback
- Inconsistent course organization
- MFA without phone access
- Exam information outside the Canvas

Baseline GRL Model: What Traditional Goal Modeling Captures



What this baseline captures

- Actors and responsibilities
- Goals, tasks, and softgoals
- Dependencies among stakeholders

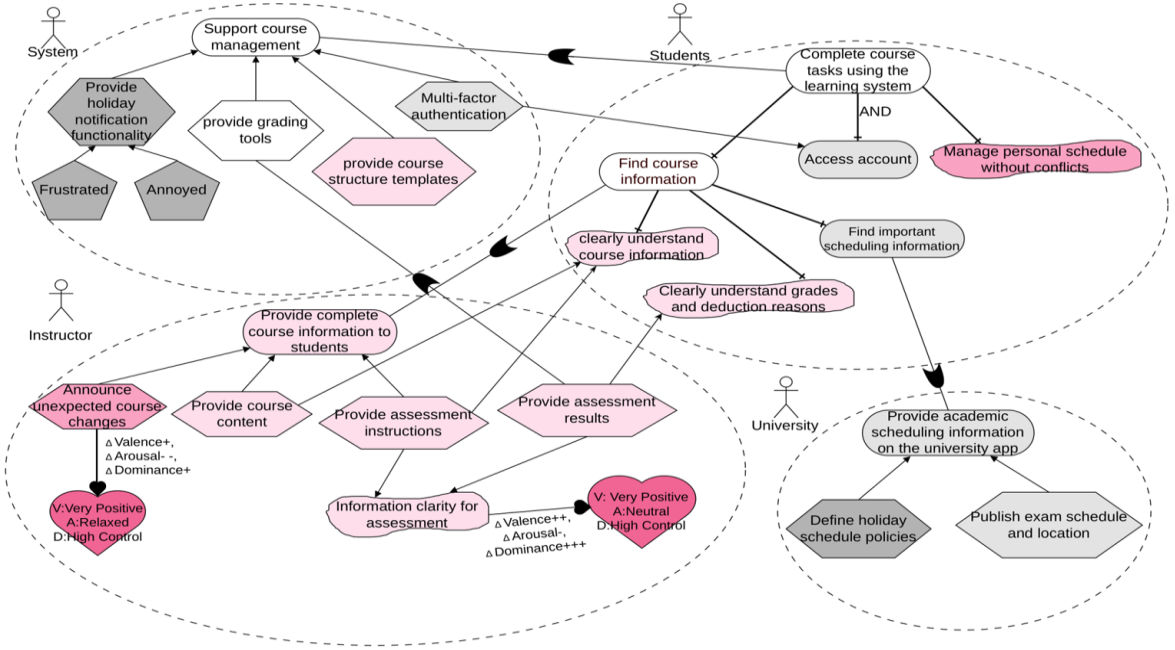
What is still missing?

The model does not show how users feel when these goals or tasks fail in practice.

Takeaway: Baseline GRL captures system intentions, but emotional effects remain implicit.

EmORE-GRL Model: Emotional Information on the Same Structure

EmORE preserves the baseline model while adding emotional constructs and valence visualization.



Valence layer
Shaded elements highlight positive, neutral, or negative emotional feedback.

High-frequency emotions
Pentagons preserve common emotion words, such as frustrated and annoyed.

Emotional goals
Hearts show the desired emotional outcome, such as high control or reassurance.

EmORE links
VAD gaps connect system elements to target emotional states.

Takeaway: The original goal model is preserved; emotional evidence becomes visible and traceable.

Case Study Finding

Analyzed Emotional Data

Scenario: Midterm grades are visible in the Canvas, but detailed feedback or explanation is not provided

VAD profile (Average Normalized Scores):
V = 51.11% (Neutral valence — could be more positive)
A = 58.89% (Neutral arousal)
D = 35.00% (Low control — needs improvement)

Mapped Elements

Provide assessment results
(The instructor makes the grades available.)
Information clarity for assessment
(Detailed feedback and explanations are missing.)
Clearly understand grades and deduction reasons
(Students cannot fully understand how marks were deducted.)

Requirement Insight & Action

Emotional goal: Very positive, Neutral, High control

Issue identified: Missing explanations and feedback reduce students' perceived control

Improvement direction: Provide detailed feedback

Validation result: Reviewed by Requirements Engineers

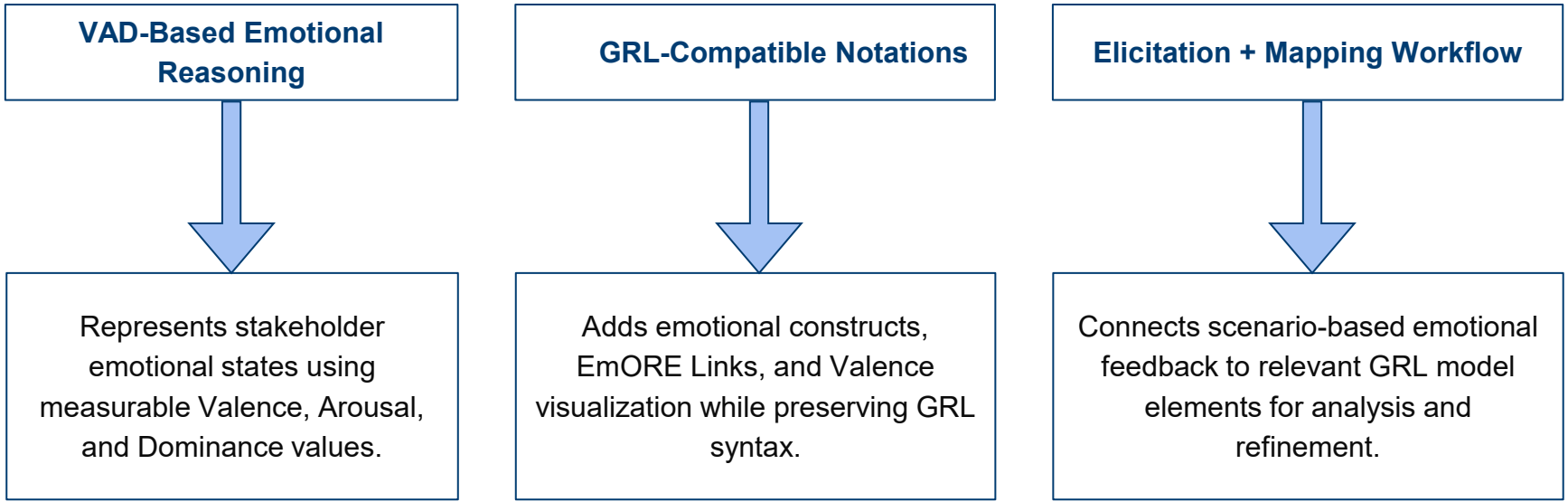
Student feedback: "A good grade makes me happy, but a lower or unexpected grade makes me want to understand the grading criteria."

EmORE turns emotional responses into traceable requirement evidence and improvement actions.

Limitations and Future Work

Key Limitations		Future Work
Limited Case-Study Scope Single-domain evaluation in a university Canvas context.	→	**Multi-Domain Validation** Apply EmORE across different domains, systems, and stakeholder groups.
Analyst-Dependent Modeling Scenario identification and emotion-to-GRL mapping involve analyst judgment.	→	**Multi-Perspective Evaluation** Involve RE experts, domain experts, stakeholders, and multiple analysts.
Dedicated Tool Support jUCMNav does not yet support custom EmORE shapes, gradients, or textures.	→	**jUCMNav Tool Integration** Implement EmORE constructs in jUCMNav to support practical modeling and model management.

Conclusion


VAD-Based Emotional Reasoning
Represents stakeholder emotional states using measurable Valence, Arousal, and Dominance values.
GRL-Compatible Notations
Adds emotional constructs, EmORE Links, and Valence visualization while preserving GRL syntax.
Elicitation + Mapping Workflow
Connects scenario-based emotional feedback to relevant GRL model elements for analysis and refinement.

THANK YOU!