How Students Perceive Professional Competencies in Software Projects: A Cyclical Study on Human Behavior in Business Process Management Context

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Abstract. *Context: Computing education must go beyond technical training to encompass the development of professional competencies. Objective: This paper aims to characterize the evolution of students' perceptions regarding the importance and difficulty of four professional competencies throughout a semester-long integrated project involving three disciplines: Business Process Management (BPM), project management, and enterprise management systems. Method: Forty-seven undergraduate students worked in multidisciplinary teams to solve real-world problems using Business Process Management Notation (BPMN) and interface prototyping. At the end of each of the four project cycles, students assessed the perceived importance and difficulty of teamwork, project planning, client negotiation, and technical challenges. The results showed that while students consistently rated all competencies as highly important, they perceived increasing difficulty over time, particularly in teamwork and project planning. This trend indicates a growing awareness of the complexity of non-technical skills. Conclusions: The use of cyclical self-assessment effectively revealed behavioral patterns and learning needs, offering valuable insights into human behavior in software education and supporting more integrated curriculum strategies.*

1. Introduction

Software development is a socio-technical activity that requires not only technical expertise but also professional and behavioral competencies [Iacob and Faily 2019, Licorish et al. 2022]. Teamwork, client negotiation, technical challenges, and project planning are essential for managing multidisciplinary teams and real-world project complexities [Bastarrica et al. 2017]. Although widely recognized as critical in computing education, these competencies are often developed in fragmented or under-assessed ways.

Authentic learning environments that simulate professional contexts and promote interdisciplinary collaboration have been shown to support competency development [Bastarrica et al. 2017, Abich et al. 2024]. Bastarrica et al. [Bastarrica et al. 2017] found that soft skills gained importance during capstone projects, yet aspects like teamwork and planning were more challenging than expected; however, their pre/post evaluation design offered limited insight into how perceptions evolve. Other studies [Iacob and Faily 2019, Maia et al. 2023] emphasize feedback, autonomy, and structured

Project-Based Learning (PBL), focusing on learning outcomes or process design rather than the longitudinal dynamics of perceptions.

To address this gap, we integrate PBL [dos Santos 2023] and Business Process Management (BPM) [Dos Santos et al. 2023] in an interdisciplinary setting, combining a BPM course and a real-world project with two additional courses [Barcellos et al. 2024]. We investigate students' evolving perceptions of four key competencies—technical challenges, teamwork, client negotiation, and project planning—across four assessment cycles, incorporating personality profiles to capture individual differences.

In this work, we conducted a longitudinal study in an in-person, 60-hour BPM course integrated with Project Management and Enterprise Management Systems, where 47 Information Systems undergraduates executed a real-client, interdisciplinary PBL project across four learning cycles. At the end of each cycle, students self-assessed the importance and difficulty of four competencies (technical challenge, client negotiation, project planning, and teamwork) enabling repeated-measures analyses and a personality-aware perspective using Keirsey profiles.

The study shows that perceived importance remained consistently high while perceived difficulty rose over time, most notably in teamwork and planning; it also reveals profile-specific patterns (e.g., Artisans' significant increase in the perceived importance of planning).

Our contributions are manifold: (i) we present a cyclic approach that extends previous studies by showing how perceptions change during the semester; (ii) we provide evidence that personality traits influence these changes, supporting more personalized and student-aware teaching strategies.

This document is structured as follows: in Section 2, the research design is described; in Section 3, the answers to our research questions are provided; and, finally, in Section 4, conclusions and future work are discussed.

2. Research Design

The following section outlines research questions, data collection, and data analysis procedures.

2.1. Research Questions

The following research questions guided the execution of this study:

RQ1: How do students' perceptions of the importance and difficulty of software engineering practices evolve across four development cycles?

RQ2: Which competencies exhibit the most significant changes in students' perception from the first to the fourth development cycle?

RQ3: Do personality profiles influence students' perceptions of the importance and difficulty of project-related competencies over time?

2.2. Interdisciplinary PBL Experience

The data used in this study were collected within an interdisciplinary Project-Based Learning (PBL) experience that integrates three courses from the undergraduate Information Systems program: Business Process Management (BPM), Project Management

(PM), and Enterprise Management Systems (EMS) [Dos Santos et al. 2023]. To address prior challenges of content misalignment and fragmented assessments, the professors collaboratively designed an integrative PBL model structured around a real-world problem-solving process. In this model, student teams work with authentic problems proposed by real clients and are guided through four learning cycles covering project planning, problem understanding, solution analysis, and solution proposition. Each cycle combines preparation, resolution, evaluation, and reflection activities, supported by content and mentoring aligned across the three disciplines.

Throughout the semester, students interact with these clients, model and analyze current (AS-IS) and improved (TO-BE) processes, and produce BPM-related artifacts including (Supplier, Input, Process, Output, Customer) SIPOC matrices, process scope diagrams, BPMN models, and performance indicators. They also collaborate with peers to develop complementary deliverables for the integrated project [Dos Santos et al. 2023], such as stakeholder analyses, communication and risk plans, and interface prototypes. The course uses a cyclical assessment strategy based on the (Plan, Do, Check, Act) PDCA model, also adopted in other courses [Liu et al. 2025], focusing on the progressive development of professional competencies. Evaluations are carried out by professors, real clients, and PBL tutors, using authentic assessments, and include student self-assessments. This structure creates a rich pedagogical setting for analyzing cyclical changes in students' perception of key competencies, as explored in this study.

2.3. Study's Context

This paper focuses on data collected from an in-person BPM course taught in Portuguese during the 2024.2 semester, with 47 fourth-semester Information Systems undergraduate students with little or no experience in business process management. The 60-hour course combines theoretical instruction, modeling exercises, and exams with the execution of an interdisciplinary PBL project, guiding students through the analysis, modeling, and improvement of business processes using BPMN, in response to real-world problems presented by external clients [Nobre and Vilela 2024].

2.4. Students' Profile

The 47 students worked in six teams of 7 to 8 members. The professor of the EMS course formed the groups using the Team Formation Method (TFM) developed by Santos et al.[dos Santos 2023], which suggests creating small, diverse teams by considering attributes such as age, gender, personality type (using MBTI-Keirsey [Shen et al. 2007]), preferred computing skills (documenting, interacting, modeling, or management), professional experience, and interpersonal affinities. This approach also aligns with the findings of previous work [Vilela et al. 2024], who explored how performance in certain soft skills varies between assessments and team formation methods.

Based on the results of the self-diagnosis, the MBTI-Keirsey profile distribution of the 37 students who participated in this study showed a predominance of Guardians, with 15 students (40.5%), followed by Rationals with 11 students (29.7%). Idealists accounted for 5 students (13.5%), while Artisans represented 6 students (16.2%). This distribution indicates a strong presence of profiles oriented toward structure, responsibility, and strategic thinking, complemented by creative, empathetic, and adaptable temperaments.

In this report, we had five groups of eight students and one group of seven students. Each group chose a different real-world problem as described in the next section.

2.5. Real-World Problems

The interdisciplinary PBL involved six real-world projects with public institutions: one with the Hospital das Clínicas[1], focused on predicting chemotherapy toxicity; two with the Instituto Federal de Pernambuco[2], developing a management indicators dashboard and improving communication management with staff; and three with the Prefeitura do Recife[3], addressing animal health, organizational sustainability, and urban tree management. These initiatives spanned diverse domains, offering students exposure to varied stakeholders, organizational contexts, and process complexities.

2.6. Data Collection and Analysis Procedures

To investigate our research questions, we collected data through four self-assessment questionnaires administered at the end of each development cycle within a semester-long project involving six real-world software initiatives and three clients. Students rated, on a scale from 0 to 100, the perceived importance and difficulty of four key aspects: technical challenge, client negotiation, project planning, and teamwork. To maintain analytical consistency, only students who completed all four questionnaires were included in the analysis, enabling the application of repeated measures techniques and avoiding bias from incomplete responses.

The questionnaire design was inspired by Bastarrica et al. [Bastarrica et al. 2017], who also used a 0–100 scale to assess perceived importance and difficulty of software engineering practices. However, unlike their pre/post methodology, our study collected responses across four distinct stages, one after each project cycle. This approach allowed for a more detailed and dynamic view of how students' perceptions changed throughout the learning experience, offering deeper insights into behavioral development during real-world inspired software projects.

To answer RQ3, we analyzed the students' MBTI-Keirsey profiles against the reported perceptions throughout the course.

3. Results

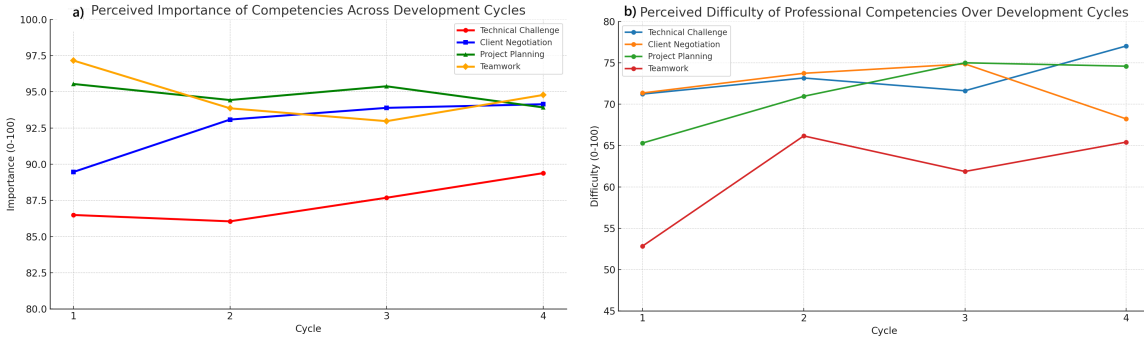
The results of our research questions are discussed in the next sections.

3.1. RQ1: How do students' perceptions of the importance and difficulty of software engineering practices evolve across four development cycles?

To investigate how students' perceptions evolved, we analyzed the average self-assessment scores for each dimension across the four development cycles, using data from the 37 students who completed all evaluations. These averages were visualized in Figure 1, which presents the trends in perceived importance and difficulty for the four evaluated dimensions: technical challenge, client negotiation, project planning, and teamwork.

[1]https://www.gov.br/ebserh/pt-br/hospitais-universitarios/regiao-nordeste/hc-ufpe
[2]https://portal.ifpe.edu.br/recife/
[3]https://www2.recife.pe.gov.br/

Figure 1. Perceived (a) importance and (b) difficulty of each project dimension across the four evaluation cycles.



Answer to RQ1: *students maintained a stable perception of importance across all four development cycles, while their perception of difficulty grew over time, reflecting a stronger, experience-driven understanding of the challenges inherent in software engineering practice. This highlights the value of cyclical, iterative learning in uncovering hidden complexities that only emerge through real-world engagement.*

3.2. RQ2: Which competencies exhibit the most significant changes in students' perception from the first to the fourth development cycle?

While RQ1 explored the evolution of students' perceptions over four cycles, RQ2 aims to identify which competencies experienced the most notable changes between the first and last cycle. To address this, we analyzed the difference in self-assessment scores between Cycle 1 and Cycle 4 for each dimension and type (importance or difficulty), considering only the 37 students with complete responses. As shown in Table 1, we calculated both absolute and percentage changes using the formula:

$$\text{Percent Change} = \frac{\text{Cycle 4 Mean} - \text{Cycle 1 Mean}}{\text{Cycle 1 Mean}} \times 100 \tag{1}$$

The results show that the most pronounced changes occurred in difficulty ratings, suggesting a growing awareness of the challenges involved in teamwork and planning as the project progressed.

Students consistently rated all four competencies as highly important throughout the project. Although Technical Challenge and Client Negotiation saw modest increases in perceived importance (+3.34% and +5.23%, respectively), there were slight declines for Project Planning (–1.70%) and Teamwork (–2.45%). These small shifts did not alter the overall perception of these skills as central to the project's success.

In contrast, perceived difficulty increased notably for most competencies, with Teamwork showing the largest rise (+23.77%), followed by Project Planning (+14.22%) and Technical Challenge (+8.16%). Only Client Negotiation showed a decline (–4.38%),

Table 1. Comparison of Perceived Importance and Difficulty Between Cycle 1 and Cycle 4

Dimension	Type	Cycle 1 Mean	Cycle 4 Mean	Std. Dev. Cycle 1	Std. Dev. Cycle 4	% Change
Technical Challenge	Importance	86.49	89.38	15.81	11.19	+3.34%
	Difficulty	71.22	77.03	21.32	16.97	+8.16%
Client Negotiation	Importance	89.46	94.14	19.18	11.12	+5.23%
	Difficulty	71.35	68.22	27.43	25.34	-4.38%
Project Planning	Importance	95.54	93.92	6.95	9.80	–1.70%
	Difficulty	65.30	74.59	25.52	24.12	+14.22%
Teamwork	Importance	97.16	94.78	6.41	7.93	–2.45%
	Difficulty	52.84	65.41	31.77	30.40	+23.77%

possibly indicating growing confidence in handling stakeholder interactions. While students became more aligned in their importance ratings (as shown by lower standard deviations), their difficulty perceptions remained diverse, reflecting individual differences in experience and adaptation over time.

Answer to RQ2: *The most significant changes in students' perceptions occurred in Teamwork and Project Planning, which showed notable increases in perceived difficulty. These results suggest that students developed a stronger and more realistic understanding of the complexities of collaboration and planning in software projects, reinforcing the importance of repeated experiential learning cycles.*

3.3. RQ3: Do personality profiles influence students' perceptions of the importance and difficulty of project-related competencies over time?

Figures 2 and 3 illustrate how students with different MBTI-Keirsey personality profiles (Guardian, Idealist, Rational, and Artisan) [Shen et al. 2007] perceived the importance and difficulty of four professional competencies throughout the project.

All profiles attributed high **importance** to competencies from the beginning, with some variation in how these perceptions evolved. For instance, Guardians showed increasing appreciation for technical challenges, while Artisans significantly increased their valuation of project planning. In contrast, Idealists and Rationals maintained high importance levels throughout but exhibited more variation in perceived difficulty.

In terms of **difficulty**, Idealists reported the largest increase across several dimensions, particularly teamwork and planning, suggesting a growing awareness of interpersonal challenges. Rationals also perceived more difficulty over time, while Guardians and Artisans were more stable.

Table 2 summarizes the paired t-tests comparing Cycle 1 and Cycle 4 for each profile. The only statistically significant change in importance was found for Artisans in project planning. While other changes were observed, they did not reach statistical significance.

Overall, the analysis shows that personality profiles affect how students perceive and adapt to project demands. Idealists and Rationals tend to report increased difficulty over time, especially in soft skills, while Artisans exhibit notable growth in the perceived

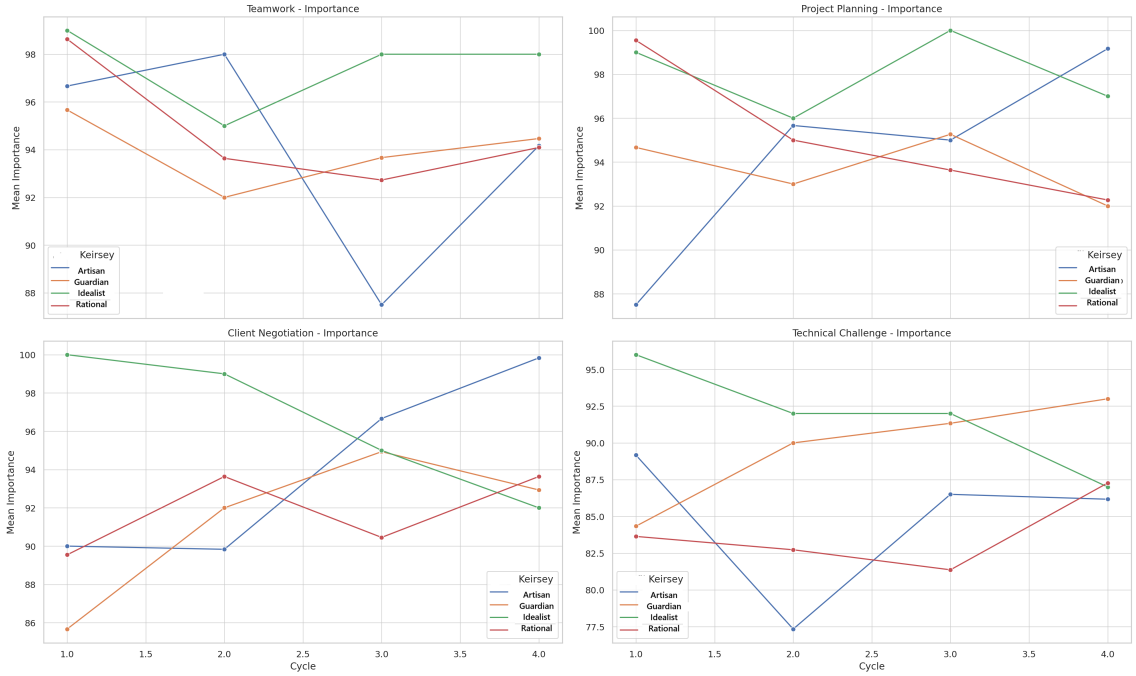


Figure 2. Evolution of the average perceived importance of each professional competency grouped by Keirsey personality profiles.

importance of planning. These distinctions suggest that instructional strategies could benefit from personalization based on personality traits.

Answer to RQ3: *Personality profiles shape how students perceive the importance and difficulty of professional competencies. While all groups initially valued the dimensions, Idealists and Rationals experienced the most notable increases in perceived difficulty, particularly for teamwork and planning. Artisans were the only group to significantly increase their importance perception for project planning. These findings underscore the potential of personality-aware instructional design to better support diverse learning experiences in project-based contexts.*

3.4. Threats to Validity

The validity of this study was examined using Wohlin's framework [Wohlin et al. 2012]. Regarding *internal validity,* a potential limitation originates from the use of self-reported data, which can be influenced by social desirability or misinterpretation of the rating scale. To reduce this risk, the same measurement instrument was consistently applied across four cycles with the same students, allowing for the tracking of perceptual changes over time. Selection bias [Vilela 2020] was mitigated through the use of the TFM method for group formation.

In terms of *construct validity*, the selected dimensions—teamwork, planning, negotiation, and technical challenges—are well-established in software project contexts. Moreover, personality was assessed using Keirsey's framework, which may not fully capture the complexity of individual behavior. *Conclusion validity* is affected by the sample size, especially when grouped by profile, limiting statistical power. Finally, *external va-*

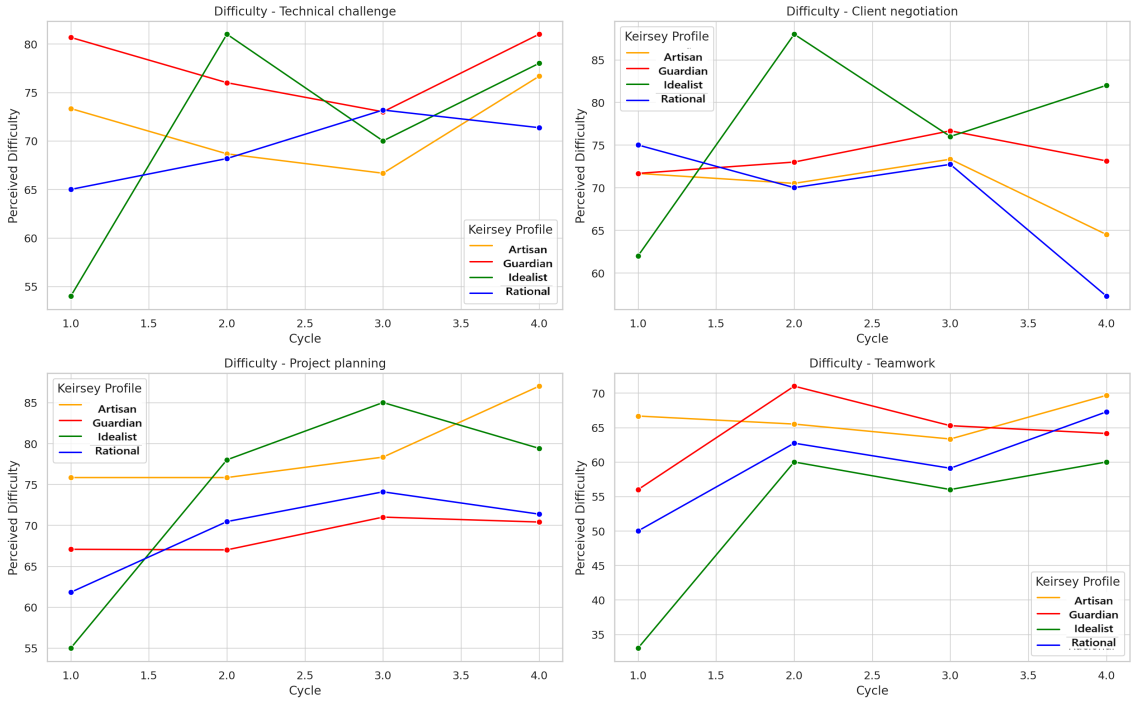


Figure 3. Evolution of the average perceived difficulty of each professional competency grouped by MBTI-Keirsey personality profiles.

lidity is constrained by the specific educational context (a single interdisciplinary BPM course in a Brazilian university) posing challenges to broader generalization without replication in diverse settings.

4. Conclusions and Future Work

This study explored students' evolving perceptions of the importance and difficulty of four key professional competencies—teamwork, project planning, client negotiation, and technical challenges—throughout a semester-long BPM course integrated with project management and enterprise systems. Based on cyclical self-assessments from 37 students, the results revealed consistently high importance ratings for all competencies, but increasing difficulty, particularly in teamwork and planning.

By incorporating MBTI-Keirsey personality profiles, the study also identified differences in how students experienced and responded to project challenges, with certain profiles showing greater sensitivity to specific aspects. These insights underscore the value of iterative, experience-based learning and point to the benefits of tailoring instructional strategies to individual student traits in software education.

As future work, we intend to replicate this study with a larger and more diverse sample across multiple semesters and institutions. We also plan to incorporate new variables such as team dynamics, leadership styles, and project complexity to further understand their influence on perceived difficulty. In addition, longitudinal studies can help assess how these perceptions evolve beyond the course, particularly during capstone projects and early professional experiences. Finally, we propose the integration of personality-aware instructional strategies to foster more inclusive and effective learning

Table 2. Summary of paired t-test results and perception patterns across profiles (Cycle 1 vs Cycle 4), grouped by Dimension and Type.

Dimension	Type	Profile	Cycle 1 Mean	Cycle 4 Mean	p-value	Summary Pattern
Client Negotiation	Difficulty	Artisan	71.67	64.50	0.167	Perception decreased.
	Importance	Artisan	90.00	99.83	0.108	High initial values; perception increased.
	Difficulty	Guardian	71.67	73.13	0.888	No major change.
	Importance	Guardian	85.67	92.93	0.297	High initial values; perception increased.
	Difficulty	Idealist	62.00	82.00	0.142	Perception increased.
	Importance	Idealist	100.00	92.00	0.099	High initial values; perception decreased.
	Difficulty	Rational	75.00	57.27	0.111	Perception decreased.
	Importance	Rational	89.55	93.64	0.654	High initial values.
Project Planning	Difficulty	Artisan	75.83	87.00	0.230	Perception increased.
	Importance	Artisan	87.50	99.17	0.013	High initial values; perception increased. Significant change.
	Difficulty	Guardian	67.07	70.40	0.740	No major change.
	Importance	Guardian	94.67	92.00	0.462	High initial values.
	Difficulty	Idealist	55.00	79.40	0.076	Perception increased.
	Importance	Idealist	99.00	97.00	0.587	High initial values.
	Difficulty	Rational	61.82	71.36	0.455	Perception increased.
	Importance	Rational	99.55	92.27	0.066	High initial values; perception decreased.
Teamwork	Difficulty	Artisan	66.67	69.67	0.822	No major change.
	Importance	Artisan	96.67	94.17	0.518	High initial values.
	Difficulty	Guardian	56.00	64.13	0.457	Perception increased.
	Importance	Guardian	95.67	94.47	0.631	High initial values.
	Difficulty	Idealist	33.00	60.00	0.159	Perception increased.
	Importance	Idealist	99.00	98.00	0.704	High initial values.
	Difficulty	Rational	50.00	67.27	0.245	Perception increased.
	Importance	Rational	98.64	94.09	0.148	High initial values.
Technical Challenge	Difficulty	Artisan	73.33	76.67	0.741	No major change.
	Importance	Artisan	89.17	86.17	0.641	High initial values.
	Difficulty	Guardian	80.67	81.00	0.960	No major change.
	Importance	Guardian	84.33	93.00	0.113	Perception increased.
	Difficulty	Idealist	54.00	78.00	0.109	Perception increased.
	Importance	Idealist	96.00	87.00	0.330	High initial values; perception decreased.
	Difficulty	Rational	65.00	71.36	0.473	Perception increased.
	Importance	Rational	83.64	87.27	0.650	No major change.

environments in project-based settings.

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