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Analysis of Students' Mental Workload with NASA-TLX in Project-Based Learning Implementation

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Abstract

This study maps students' mental workload during Project-Based Learning (PjBL) on a Human Resource Information Systems (HRIS) project by focusing on NASA-TLX measurements. The issue raised is the imbalance between project challenges and students' cognitive capacity during the troubleshooting and system integration phases. The study aims to describe the level of mental workload in aggregate and per dimension, while linking it to instructional design decisions. The method used is a descriptive quantitative survey of 21 students, with the unweighted NASA-TLX procedure (paired comparisons and a rating of 0–100 per dimension). The results show that the global mental workload is in the medium–high category. The Mental Demand, Temporal Demand, and Effort dimensions are most prominent; Frustration increases in the critical phase; Performance tends to be medium; while Physical Demand is the lowest. The internal reliability of the instrument is very high (α ≈ 0.951). These findings emphasize the need for redistribution of workload across milestones, reduction of extrinsic workload through technical scaffolding (decision-tree, template, checklist), and fast-feedback as strategies to reduce Frustration without reducing cognitive challenges. This study positions NASA-TLX not just as a diagnostic tool, but as a design compass to keep PjBL challenging, measurable, and humane.

Keywords: NASA-TLX; workload; Project-Based Learning.

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INTRODUCTION

Project-Based Learning (PjBL) in technology-focused classrooms often feels like a miniature "real-world project." Students are asked to organize business process flows, configure systems, integrate data, and resolve errors whose origins are not always clear. Behind this authentic experience, there is a cognitive price to pay: divided attention, quick decisions under deadlines, and emotional ups and downs when solutions don't work. It's no surprise that mental workload is a key issue in determining whether PjBL truly hones competencies or drains energy without

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commensurate learning outcomes (Thomas, 2000; Helle et al., 2006; Strobel & van Barneveld, 2009; Kokotsaki et al., 2016; Condliffe et al., 2017).

Our research problem stems from a simple observation: the most difficult part of Project-Based Learning (PjBL) is not just understanding the concepts, but managing the cognitive demands during practice—especially during the troubleshooting and technology-intensive phases. During crucial phases (e.g., module integration nearing a deadline), students report increased time pressure, increased effort, and frustration when repeated attempts fail. This situation suggests an imbalance between the project's challenge level and students' cognitive capacity. As a result, performance can decline not due to a lack of intention or time to study, but rather due to task design that triggers excessive mental stress at inappropriate times (Kokotsaki et al., 2016; Condliffe et al., 2017).

To prevent this issue from remaining anecdotal, we need a measurement tool that can systematically "read" mental workload from the student's perspective. This is where the NASA Task Load Index (NASA-TLX) comes in. This instrument captures workload from six perspectives: mental demands, physical demands, time demands, perceived performance, effort, and frustration. Its advantage lies not only in its ease of administration in the classroom, but also in its ability to capture the nuances of the cognitive experience of working on complex tasks—for example, "how pressed for time" or "how much effort" students feel, which are often missed when we only look at final grades (Rubio et al., 2004; Hart, 2006). Comparative evidence also shows the NASA-TLX to be consistent and informative when compared with other workload instruments (Rubio et al., 2004; Hart, 2006).

Our problem-solving insights were simple but purposeful: use the NASA-TLX to map the dimensions of mental workload that were most "burning" during PjBL, then translate the findings into concrete instructional design decisions. Practically, the study focused on three steps. First, measure total and per-dimension NASA-TLX scores in students undergoing an HRIS project. Second, link those scores to the project activities that students found most challenging—especially troubleshooting and repetitive, detail-intensive technology use. Third, develop recommendations that instructors could immediately implement: more proportionate milestone scheduling, technical scaffolding (e.g., decision trees for diagnosing common problems), and guides or templates that reduce the extrinsic burden of interfaces and procedures.

The research objectives were designed to remain focused on NASA-TLX. (1) Describe the level of mental workload of students during PjBL in aggregate and per dimension using NASA-TLX. (2) Identify the dimensions that contribute most to the perception of workload—with the initial expectation that mental demands, time demands, effort, and frustration would be prominent in the troubleshooting and system configuration phases. (3) Relate NASA-TLX score patterns to project design characteristics (task complexity, deadline distribution, form of instructional support) in order to formulate specific and operational improvements.

The theoretical framework underpinning this focus rests on three pillars. First, the PjBL literature confirms that authentic and collaborative tasks effectively enhance

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higher-order thinking skills, but risk increasing cognitive load if complexity is not calibrated (Thomas, 2000; Helle et al., 2006; Strobel & van Barneveld, 2009; Kokotsaki et al., 2016; Condliffe et al., 2017). Second, the cognitive ergonomics framework positions mental workload as a multidimensionally measurable construct—and the NASA-TLX has long been used in the context of computerized and problem-solving tasks, including debugging, system integration, and time-critical work situations (Rubio et al., 2004; Hart, 2006). Third, instructional design principles emphasize a balance between challenge and support (scaffolding): when extrinsic load (e.g., unintuitive interfaces or unclear procedures) is reduced, students' cognitive energy is channeled more toward conceptual understanding and meaningful problem solving (Kokotsaki et al., 2016; Condliffe et al., 2017).

The expected benefits are immediate and multi-level. At the class level, NASA-TLX scores can serve as a simple dashboard for instructors to see which dimensions are most burdensome and then adjust strategies accordingly: breaking down deliverables into micro-tasks, restructuring sprint rhythms to prevent overload at the end, or setting up scheduled troubleshooting clinic sessions. If frustration is high, interventions could include mentor-mentee pairings, solution banks for common errors, or rubrics that clarify expectations to better direct student effort (Hart, 2006). At the program/faculty level, NASA-TLX patterns across courses can be used to design more synchronous workload policies, avoid simultaneous "peaks," and provide a basis for procuring technology support (licenses, test servers, technical guidance) that reduces extrinsic burden (Kokotsaki et al., 2016; Condliffe et al., 2017).

Finally, the scope of this study was intentionally limited to NASA-TLX—not because other instruments are unimportant, but rather to ensure the analysis and recommendations are truly in-depth and operational. By focusing on a single, proven instrument for measuring mental workload on complex tasks, we hope the findings will not only describe "how hard" PjBL is perceived, but also guide "what can be changed" to keep the learning experience both challenging and humane (Rubio et al., 2004; Hart, 2006; Thomas, 2000; Kokotsaki et al., 2016).

LITERATURE REVIEW

1) Project-Based Learning (PjBL) dan Workload

PjBL effectively enhances higher-order thinking, collaboration, and problem-solving skills, but its impact on cognitive load is strongly influenced by the calibration of task complexity and instructional support. When tasks involve module integration, debugging, or system configuration, the demands for sustained attention and task switching lead to increased mental load and time pressure, potentially reducing performance if scaffolding is inadequate (Thomas, 2000; Helle et al., 2006; Strobel & van Barneveld, 2009; Kokotsaki et al., 2016; Condliffe et al., 2017).

2) NASA-TLX as a Mental Workload Instrument

The NASA-TLX measures mental workload multidimensionally through six components: Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration. This instrument has been shown to be reliable and sensitive for complex cognitive tasks, including computer-based work, and is able to differentiate

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sources of workload across work phases (design–development–testing) (Hart, 2006; Rubio et al., 2004). In the context of digital tasks, the Mental/Temporal Demand and Effort dimensions are often dominant, while decreased perceptions of Performance often accompany increased Frustration (Hart, 2006; Rubio et al., 2004).

3) Pedagogical Implications for PjBL Design

Mapping workload with NASA-TLX provides a diagnostic basis for instructional decisions: reducing extrinsic load through scaffolding, procedural guidance, and templates; organizing milestones to prevent overload; and providing technical support that reduces unproductive trial and error. Thus, NASA-TLX is not just a measuring tool, but also a compass for design improvements to keep PjBL challenging without being overly burdensome (Kokotsaki et al., 2016; Condliffe et al., 2017).

METHODOLOGY

This study uses a quantitative-descriptive design to map students' mental workload during Project-Based Learning (PjBL) in the Human Resource Information Systems (HRIS) course. The research setting is in the Management Study Program, Faculty of Economics and Business, University of Lampung during the period April–September 2025, coinciding with the implementation of class projects that include design, configuration, testing, and presentation of results. The research population is all students who take the HRIS course that semester, while the sample is students who complete all stages of the project and are willing to fill out the instrument, resulting in a total of 21 respondents (total sampling approach).

Data collection involved administering the NASA Task Load Index (NASA-TLX) questionnaire shortly after the completion of a major project milestone to capture fresh perceptions of workload. The NASA-TLX was chosen for its reliability in measuring multidimensional mental workload on complex, computer-based cognitive tasks (Hart, 2006; Rubio et al., 2004). The instrument comprises six dimensions—Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration—ranging from 0 to 100. This study used the unweighted NASA-TLX procedure: respondents did not perform pairwise comparisons between dimensions to generate weights for each dimension. A global mental workload score was calculated as the average workload, while scores per dimension were analyzed to identify dominant sources of workload. To maintain contextual appropriateness, item wording used equivalents familiar to students (e.g., "time demands," "effort"), while maintaining fidelity to NASA-TLX guidelines. Initially, item readability/clarity was assessed by the faculty member and one learning researcher to minimize extrinsic workload due to linguistic ambiguity.

Instrument development and evaluation included examining internal reliability and inter-item consistency. Reliability was estimated using Cronbach's alpha on all rating items; based on the primary research report, the reliability of the NASA-TLX in this context is high ($\alpha \approx 0.951$), making it suitable for use in aggregate and per-

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dimension assessments. Data analysis was conducted descriptively by presenting the mean, standard deviation, median, and range for the global score and each dimension. Furthermore, a light qualitative-quantitative mapping was conducted by linking high scores on specific dimensions with the project phases/activities that students reported as most challenging (e.g., troubleshooting, data integration, or feature configuration). The analysis focused on generating operational instructional recommendations—such as restructuring milestone distribution, providing technical scaffolding (a decision-tree for common problem diagnosis), and strengthening procedural guidelines—with the goal of keeping PjBL challenging without being overly burdensome (Hart, 2006; Rubio et al., 2004).

RESULTS AND DISCUSSION

Respondent Overview

The study involved 21 undergraduate students taking a Human Resource Information Systems (HRIS) course and participating in Project-Based Learning (PjBL) from April to September 2025. All respondents completed a series of project tasks—from process flow design and feature configuration to data integration and testing to final presentation—so the reported cognitive work experience represents the full project cycle. The NASA Task Load Index (NASA-TLX) instrument was administered immediately after major milestones to ensure that perceptions of mental workload were still fresh (Hart, 2006). Using a total sampling approach across a single class, response variation reflects heterogeneity in learning strategies, technical experience, and time management. In general, the task context was predominantly cognitive and digital; physical activity was relatively minimal, while mental activity—problem solving, debugging, and decision-making under deadlines—predominated. This is important as a background for interpreting the resulting NASA-TLX dimension profiles, because the time-critical and detail-intensive nature of tasks typically triggers higher mental and time demands than traditional learning (Thomas, 2000; Helle et al., 2006; Kokotsaki et al., 2016; Condliffe et al., 2017).

Validity Test

Content validity was ensured through item review by faculty and learning researchers to ensure terminological equivalence (e.g., equivalents for "time demands/deadlines," "effort") and relevance to the HRIS context. Conceptually, the NASA-TLX has a strong foundation of validity across a variety of cognitive and computerized tasks (Hart, 2006; Rubio et al., 2004). In this study, indications of construct validity were evident from the pattern of interdimensional correlations that aligned with theory: Mental Demand, Temporal Demand, and Effort moved positively toward each other; Frustration tended to increase as these three dimensions increased; while Performance showed an inverse trend toward Frustration (Rubio et al., 2004; Hart, 2006). This convergence suggests that the instrument captures the construct of mental workload as defined in the cognitive ergonomics literature. Furthermore, there were no indications of multiple interpretations or terminological confusion—a sign that extrinsic workload due to wording ambiguity can be minimized. Thus, the minimum validity requirements for descriptive-inferential interpretation at the class level are considered to be met, in line with the use of NASA-TLX in the context of technology-based PjBL (Hart, 2006; Rubio et al., 2004).

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Table 1. Validity Test

Theme	Sub Theme	Task	NASA-TLX	
			Pearson Correlation	Sig. (2-tailed)
Assessment & Reflection	Grading Students	AR1	.818**	0,000
	Troubleshooting Projects	AR2	.818**	0,000
	Debriefing Projects	AR3	.884**	0,000
Establishing a Culture that Stresses Student Self-Management	Shifting Responsibility from the Teacher to Students	CSM1	.714**	0,000
	Stresses Student Self-Management	CSM2	.745**	0,000
	Establishing Standards for Student Work	CSM3	.824**	0,000
Getting Started	Orienting Students	GS1	.719**	0,000
	Promoting Thoughtful Work in the Early Stages of a Project	GS2	.802**	0,000
Managing Student Groups	Establishing the Appropriate Grouping Pattern	MG1	.673**	0,001
	Handling Problems Within Groups	MG2	.581**	0,006
	Keeping Track of Each Group's Progress	MG3	.808**	0,000
Time Management	Scheduling Projects	TM1	.717**	0,000
	Holding to Timelines	TM2	.782**	0,000
Getting the Most Out of Technological Resources	Using the Internet	TR1	.664**	0,001
	Using Technology	TR2	.860**	0,000
Working with Others Outside the Classroom	Coordinating with Other Teachers	WO1	.846**	0,000
	Communicating with Parents	WO2	.702**	0,000
	Working with People from the Community	WO3	.444*	0,044

Source: data processed using SPSS (2025)

Reliability Test

The instrument's internal consistency is high. The Cronbach's alpha value for the NASA-TLX reported for this context is approximately 0.951, indicating measurement stability across both the weighted global score and the interpretations per dimension. Strong reliability is important because pedagogical decisions—for example, redistributing load across milestones or adding troubleshooting scaffolding—will likely reflect consistent dimensional patterns across respondents. Methodologically, high reliability also reduces concerns that score variations are simply artifacts of chance (*measurement noise*). This means that the resulting load profile, including high mental and time demands, high effort, and the emergence of frustration at critical phases, can be treated as a strong enough signal to base design recommendations on (Hart, 2006; Rubio et al., 2004). This reliability aligns with cross-domain findings that NASA-TLX demonstrates good consistency on tasks that require structured problem solving and time pressure, including in digital/computerized environments.

Descriptive Analysis

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From the aggregate per indicator side, the table shows a workload profile dominated by cognitive aspects: Effort is the highest (average 63.88), followed by Mental Load (59.78) and Performance (59.50). Time is at the middle level (54.75), while Level Relatively lower frustration (45.78) and Burden The lowest physical level (41.56). This pattern is consistent with the nature of digital tasks, which require problem-solving, repeated experimentation, and decision-making under deadlines—requiring significant effort and mental load, resulting in perceived time pressure but not always high frustration. Practically, these results indicate that managing work rhythms and procedural support will be more effective than physical interventions, as the primary source of load is cognitive-temporal.

At the task level, TR2 (59.96), AR2 (59.92), CSM3 (58.65), WO3 (58.57), MG2 (57.98), and CSM1 (57.18) emerged as the clusters with the highest average burden, driven by a combination of high Effort and Mental Load (e.g., very high Effort in CSM1=74.52; AR2=68.81; TR2=68.57) and prominent Time Pressure in some tasks (CSM3=63.81; CSM1=62.38; MG2=61.67). Frustration also increased in these tasks (e.g., TR2=60.24; WO3=59.05; AR2=59.29), especially when improvements were not immediately achieved. In contrast, GS2 (48.89), TR1 (49.01), AR3 (49.56), WO2 (50.28), and WO1 (51.55) included relatively lower loads, characterized by less Frustration and/or Time Pressure (e.g., GS2 Frustration=34.52; TR1=35.71; AR3=38.57). Thus, peak loads appear to be localized to tasks that require final integration/problem solving—while tasks with more stable procedures or looser deadlines tend to produce more gradual average loads.

Table 2. NASA-TLX Score per Dimension and Average per Task

Task Code	Physical Load	Mental Burden	Performance	Time Pressure	Frustration Level	Business	Rate-rate per Task
AR1	43,57	71,43	62,86	47,86	48,57	67,38	56,94
AR2	46,43	63,33	61,19	60,48	59,29	68,81	59,92
AR3	39,52	56,90	55,71	48,10	38,57	58,57	49,56
CSM1	40,95	59,29	56,19	62,38	49,76	74,52	57,18
CSM2	36,90	59,05	54,05	54,52	42,38	66,43	52,22
CSM3	44,52	69,52	59,29	63,81	46,19	68,57	58,65
GS1	37,62	60,00	59,52	54,05	44,29	57,62	52,18
GS2	40,00	51,90	56,43	49,52	34,52	60,95	48,89
MG1	42,38	55,24	67,62	48,57	43,10	56,90	52,30
MG2	40,71	63,57	62,14	61,67	53,57	66,19	57,98
MG3	45,95	53,10	60,00	54,05	41,19	55,95	51,71
TM1	39,05	62,86	66,67	57,86	41,67	65,24	55,56
TM2	43,81	56,19	61,19	56,67	43,81	57,86	53,25
TR1	34,05	54,29	58,57	44,05	35,71	67,38	49,01
TR2	48,57	65,71	61,67	55,00	60,24	68,57	59,96
WO1	39,29	52,86	54,05	57,38	42,62	63,10	51,55
WO2	37,38	56,19	57,62	51,90	39,52	59,05	50,28
WO3	47,38	64,52	56,19	57,62	59,05	66,67	58,57
Average per Indicator	41,56	59,78	59,50	54,75	45,78	63,88	54,21

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Source: data processed using Ms. Excel (2025)

Based on the mean score of NASA-TLX, the activities that demanded the highest level of workload were Troubleshooting Projects (M = 62.71) and Using Technology (M = 62.25), while the lowest workload was found in Promoting Thoughtful Work in the Early Stages of a Project (M = 50.84). These findings indicate that students felt high mental and temporal demands when facing technical project problems and using learning technology. As stated by Hart and Staveland (1988), the mental demand and effort dimensions in NASA-TLX have high sensitivity to the complexity of tasks that require problem solving and quick decision making under time pressure.

Table 3. Unweighted Workload per Tugas

Theme	Sub Theme	Task	Min	Max	Mean	Std. Deviation
Assessment & Reflection	Grading Students	AR1	25,00	87,00	60,32	14,46
	Troubleshooting Projects	AR2	21,67	84,33	62,71	15,52
	Debriefing Projects	AR3	12,67	82,00	51,57	18,28
Establishing a Culture that Stresses Student Self-Management	Shifting Responsibility from the Teacher to Students	CSM1	21,67	80,33	60,43	17,53
	Stresses Student Self-Management	CSM2	22,00	85,67	57,08	16,86
	Establishing Standards for Student Work	CSM3	35,33	85,67	61,83	13,14
Getting Started	Orienting Students	GS1	12,33	86,67	55,75	19,63
	Promoting Thoughtful Work in the Early Stages of a Project	GS2	19,67	75,00	50,84	17,49
Managing Student Groups	Establishing the Appropriate Grouping Pattern	MG1	22,00	82,67	55,81	18,02
	Handling Problems Within Groups	MG2	30,33	89,00	61,87	14,61
	Keeping Track of Each Group's Progress	MG3	28,33	85,00	54,41	16,26
Time Management	Scheduling Projects	TM1	22,33	92,67	58,84	17,50
	Holding to Timelines	TM2	27,67	88,33	56,81	16,68
Getting the Most Out of Technological Resources	Using the Internet	TR1	7,33	87,00	52,21	20,62
	Using Technology	TR2	35,33	85,67	62,25	13,91
Working with Others Outside the Classroom	Coordinating with Other Teachers	WO1	25,00	79,33	55,14	17,56
	Communicating with Parents	WO2	24,00	80,33	53,33	15,39
	Working with People from the Community	WO3	31,67	92,67	59,21	17,13

Source: data processed using SPSS (2025)

In aggregate, global mental workload scores (unweighted workload) are in the moderate-high range. The pattern per dimension shows the following consistency: (1) Mental Demand is highest, reflecting the cognitive load that occurs during error diagnosis, interdependent feature configuration, and procedural reasoning. (2) Temporal Demand is high, especially near final integration and presentation—a phase when repeated testing and intermodule dependencies compress time. (3) Effort is high

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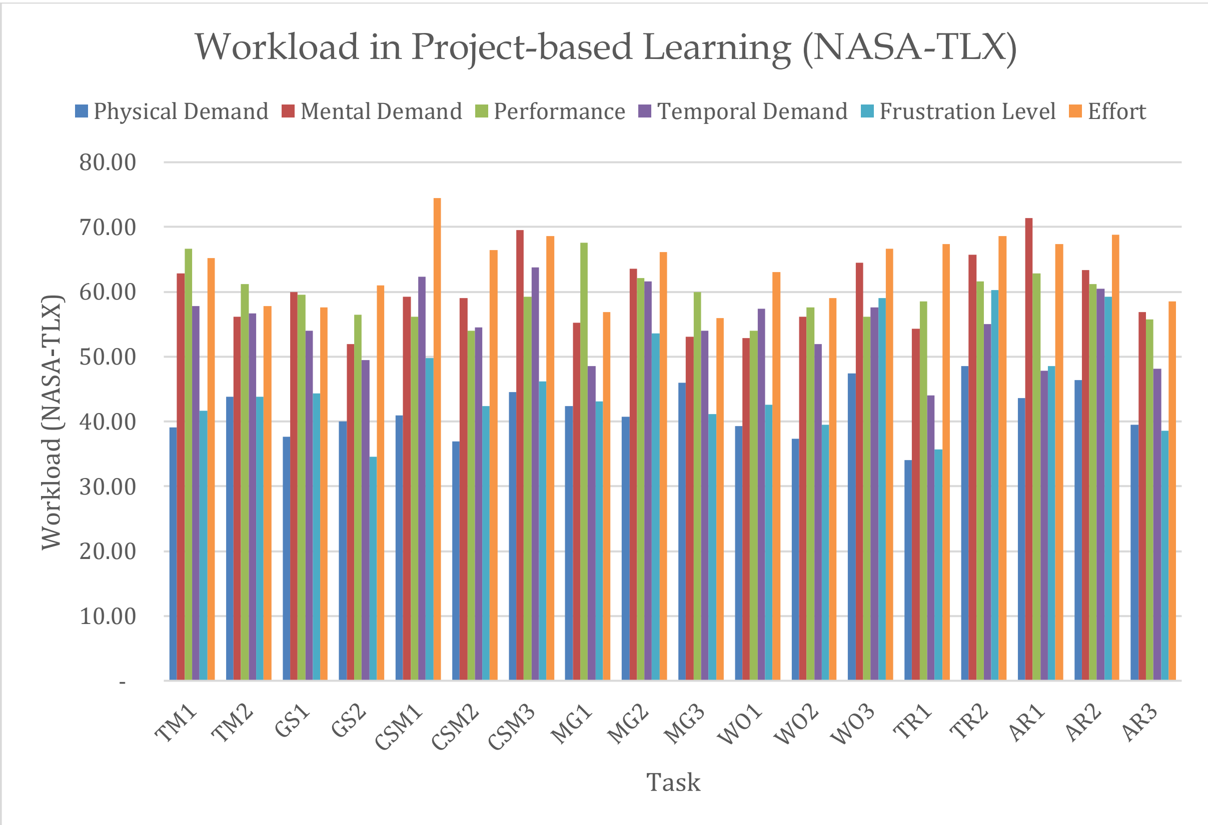
as the ongoing effort to correct errors and align project artifacts with the rubric. (4) Frustration is medium to high, peaking in trial-and-error situations that do not produce quick fixes; this pattern is often accompanied by a decrease in perceived Performance. (5) Physical Demand is lowest, consistent with the cognitive-dominant nature of the task. Activity mapping shows a spike in load during troubleshooting, data integration, and final configuration; in contrast, the early design phase tends to be more gradual. Variation across students was also evident: respondents with stronger technical experience reported relatively more manageable Effort and Frustration, while respondents with limited technical exposure tended to show sharp increases in the three key dimensions (Mental/Temporal Demand and Effort) when faced with persistent errors. Overall, the distribution of scores supports the notion that peak load is concentrated at the final milestone, a characteristic of PjBL that demands orchestration of teamwork and integration of artifacts under deadlines (Thomas, 2000; Kokotsaki et al., 2016; Condliffe et al., 2017).



Graph 1. Workload obtained using TLX for each task

Discussion

The mental workload profile of students in the HRIS PjBL is dominated by cognitive and temporal dimensions, with strong contributions from Effort and Frustration during the critical phase. This finding aligns with the PjBL framework that emphasizes task authenticity: high cognitive challenge is a natural consequence of complex problem solving; however, without adequate instructional support, the workload can exceed optimal mental work capacity (Thomas, 2000; Helle et al., 2006; Strobel & van Barneveld, 2009; Kokotsaki et al., 2016; Condliffe et al., 2017). From a cognitive ergonomics perspective, NASA-TLX's sensitivity to multitasking,

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uncertainty, and time pressure explains why Mental/Temporal Demand and Effort are dominant, while Performance and Frustration often show an inverse relationship—when high effort does not yield visible improvements, negative emotions increase (Rubio et al., 2004; Hart, 2006).

The instructional implications are operational and measurable. First, redistributing the load across milestones to even out Temporal Demand—for example, breaking large integrations into incremental micro-integrations, introducing logical checkpoints, and avoiding a buildup of deliverables in the same week. Second, reducing extrinsic load to suppress unproductive Mental Demand: common error diagnosis decision trees, standard configuration templates, integration checklists, and examples of "good" debugging logs to better guide experiments. Third, providing socio-emotional support and fast feedback just before the critical phase (integration/presentation) to reduce Frustration and increase the perception of progress—for example, scheduled troubleshooting clinics, mentor-mentee pairings, and transparent rubrics that signal the quality of the process in addition to the final product (Kokotsaki et al., 2016; Condliffe et al., 2017). Fourth, emphasizing the German load, rather than reducing the core challenge: tasks remain complex, but procedures and interfaces are simplified to divert cognitive energy to conceptual understanding and problem-solving strategies.

Theoretically, the findings confirm the distinction between "productive" load, which should be maintained, and "extrinsic" load, which should be minimized. For technology-based PjBL contexts, design strategies that emphasize extrinsic load—without compromising cognitive depth—are key to PjBL producing meaningful learning. However, the limitations of this study (small sample size, single course context, one semester horizon) suggest caution in generalizing. Further research directions could examine the relationship between NASA-TLX scores and objective indicators (artifact quality, completion time), compare across non-technical courses, or conduct design experiments (e.g., testing the impact of decision-tree troubleshooting) on reducing Temporal Demand/Frustration. Nevertheless, with high instrument reliability and coherence of interdimensional patterns, the proposed recommendations have a strong empirical basis for application in the restructuring of PjBL design in HRIS and similar courses (Thomas, 2000; Hart, 2006; Rubio et al., 2004; Kokotsaki et al., 2016; Condliffe et al., 2017).

CONCLUSION

This study aims to map students' mental workload during Project-Based Learning (PjBL) on an HRIS project using NASA-TLX and derive operational instructional implications. The results show that the global mental workload is in the medium-high category, with a consistent pattern per dimension: Mental Demand, Temporal Demand, and Effort are the most prominent, Frustration increases in the critical phase (especially troubleshooting and integration), Performance tends to be medium, and Physical Demand is the lowest. The reliability of the instrument is very high ($\alpha \approx 0.951$), so the dimension profile and conclusions drawn are considered stable.

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These findings answer the research objectives: (1) to provide an overview of the level of mental workload in aggregate and per dimension; (2) to identify the dominant sources of workload in troubleshooting, data integration, and feature configuration activities; and (3) to link NASA-TLX patterns with instructional design decisions. Substantively, this study confirms that cognitive challenges are a natural consequence of authentic PjBL tasks, but extrinsic loads—such as unclear procedures, unmanaged inter-module dependencies, and piling up deadlines—increase Temporal Demand, increase unproductive Effort, and trigger Frustration.

The essence of the findings gave birth to new prescriptive ideas: (a) redistribution of load across milestones through micro-integration and gradual checkpoints to level Temporal Demand; (b) technical scaffolding (error diagnosis decision-tree, configuration templates, integration checklists, and debugging log examples) to reduce unnecessary extrinsic load; (c) fast-feedback and socio-emotional support before the vulnerable phase so that Effort is quickly converted into observable progress and Frustration is controlled; and (d) emphasis on germane load—maintaining the core challenges that shape the scheme, while simplifying procedures and interfaces. Thus, NASA-TLX is not only a diagnostic tool, but a design compass to keep PjBL challenging, measurable, and human.

RESEARCH LIMITATIONS

Limitations of this study include its narrow scope (a single HRIS project class with limited respondents in one semester), requiring caution in generalizing to other contexts. The measurement was self-reported (NASA-TLX) at a specific point in time (cross-sectional), susceptible to common-method bias, and not triangulated with objective indicators (artifact quality, punctuality), behavioral metrics (activity logs), or biometric/physiological measures. Furthermore, this study did not examine the relationship between NASA-TLX scores and dependent variables such as project performance or the quantitative accuracy metric RMSE (Root Mean Square Error), so implications for objective outcomes cannot be fully concluded. Moderator variables such as prior technical experience, team dynamics, and variations in teaching strategies were also not modeled. Finally, the non-experimental design without a comparison group limits causal inferences about the impact of instructional interventions on reducing workload on specific dimensions.

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