https://doi.org/10.15446/ing.investig.115837

Engineering Education

Understanding How Software Project Managers Learn Using Kolb's Learning Style Inventory

Entendiendo cómo aprenden los gestores de proyectos de *software* mediante el inventario de estilos de aprendizaje de Kolb

Mauricio Hidalgo[1], Laura M. Castro[2], and Hernán Astudillo[3]

ABSTRACT

Teaching project managers involves conveying complex concepts in an accessible manner while fostering strategic thinking and promoting problem-solving skills using specific methodologies. Additionally, continuing education requires techniques for meaningful learning that balance theory with practice and build upon professional experience. However, unlike other software development roles, little is understood about how software project managers (SPMs) can learn effectively. Therefore, this research aimed to identify teaching techniques that better align with SPMs' learning styles. Kolb's learning styles test was administered to 27 project managers to determine their preferences in this regard. The surveyed SPMs leaned towards abstract conceptualization, exhibiting a balance between active experimentation and reflective observation, with the *thinking* style best reflecting these preferences. Building on this, some SPM-centered teaching guides were adapted from existing knowledge on teaching professionals with Kolb's *thinking* learning style.

Keywords: Software engineering education, project managers, continuing education, learning styles, Kolb's learning style inventory

RESUMEN

Enseñar a los gestores de proyectos implica transmitir conceptos complejos de manera accesible, fomentando el pensamiento estrategico y promoviendo habilidades de resolucion de problemas mediante metodologıas especıficas. Ademas, la educacion continua requiere tecnicas de aprendizaje significativo que brinden un balance entre la teorıa y la practica y construyan sobre la experiencia profesional. Sin embargo, a diferencia de otros roles en el desarrollo de *software*, existe un conocimiento limitado sobre la manera en que los gestores de proyecto de *software* (SPMs) aprenden de manera efectiva. Por ende, esta investigacion tuvo como objetivo identificar las tecnicas de enseñanza que mejor se alineen con los estilos de aprendizaje de los SPMs. Se aplico la prueba de estilos de aprendizaje de Kolb a 27 gestores de proyecto para determinar sus preferencias en este aspecto. Los SPMs encuestados se inclinaron hacia la conceptualizacion abstracta, presentando un balance entre la experimentacion activa y la observacion reflexiva. El estilo *thinking* fue el que mejor represento estas preferencias. Con base en esto se adaptaron algunas guıas de enseñanza centradas en SPMs a partir del conocimiento existente sobre la enseñanza para profesionales con el estilo de aprendizaje *thinking* de Kolb.

Palabras clave: Educacion para la ingenierıa de *software*, gestores de proyecto, educacion continua, estilos de aprendizaje, inventario de estilos de aprendizaje de Kolb

Received: July 17_th 2024
Accepted: January 15_th 2025

Introduction

A software project manager (SPM) is responsible for leading a team of developers and ensuring that projects are completed on time and within the desired scope. Leadership, technical knowledge, and experience allow the SPM to manage the team in an ever-evolving technological landscape, and continuous education serves as an *open door* to further develop these skills. Didactic approaches have been designed to meet specific academic needs [5], and traditional software engineering curricula can benefit from integrating specific software project management knowledge, such as the Software Extension to the PMBOK Guide, in order to better align with industry requirements [21]. While a simple theoretical approach may seem clear, facilitating the acquisition of new tools, methodologies, and best practices through continuous education is not without challenges. Software project management education (SPME) is essential for providing students with appropriate competencies to effectively serve as professionals in the software industry [12]. Although the teaching model based on course objectives is a traditional standard for software project management courses [35], key insights for SPMs extend beyond these objectives:

- Determining the problem, evaluating design alternatives, and using appropriate process models [9].
- Planning and estimating, measuring and controlling, leading and communicating, and managing risk [11].

[1]PhD in Informatics Engineering. Affiliation: Academic researcher, Universidad Finis Terrae, Chile. E-mail: mhidalgo@uft.cl
[2]PhD in Computer Science. Affiliation: Professor, Universidade da Coruña, Spain. E-mail: lcastro@udc.es
[3]PhD in Information and Computer Science. Affiliation: Research professor, ITiSB-Universidad Andrés Bello, Chile. E-mail: hernan.astudillo@unab.cl

- Using digital communication channels to develop knowledge collection and sharing [2].
- Leadership, team building, human resource policies, and project learning tools [4].

Continuous education, learning, and improvement are key principles in software project management, which are aimed at ensuring software success and longevity [34]. The collaborative, complementary, sustained, and simultaneous learning principles of continuous education for SPMs can yield significant benefits [3], but, after all, one challenge remains: ***How can a meaningful teaching and learning process for SPMs be achieved?***

For swift reference, this paper is organized as follows. Section Context and research question presents the context, a description of Kolb's learning style inventory (KLSI), and the research objectives and question. Section Related work reviews related works in the field of SPME. Section Research method: survey outlines the research methodology, including the use of KLSI to assess the learning preferences of SPMs. Section Results presents the results of a survey applied within the framework of this research, as well as the identified learning style of the SPM sample, and it proposes tailored educational strategies. Section Experimental validation presents the results obtained for the experimental validation of the proposed learning strategies, which were tested in a postgraduate course over four sessions, with a focus on assessing their relevance for the students. In addition, Section Threats to validity and limitations discusses the study's limitations and threats to validity { considering external, internal, conclusion, and construct validity. Finally, Sections Discussion, Conclusions, and Future Work discuss the implications of our results for improving SPME, present the conclusions of this work, and suggest directions for future research, respectively.

Context and research question

The role of an SPM is multifaceted and evolves with technological advancements and industry demands. This profession requires a blend of organizational prowess, strategic planning, and adept communication to oversee and steer the development of intricate software projects. The skills required for an SPM include:

- Adaptability to new technologies, methodologies, and changing project requirements [27].
- Strong leadership, technical, and analytical skills, as well as decision-making abilities, to understand and manage the complexities of software development projects [17, 28].
- Interpersonal and communication skills for managing teams and stakeholders and ensuring project requirements [27, 30].
- Soft skills, including negotiation, conflict resolution, team motivation, and emotional intelligence [10, 22, 30].

The above-presented { non-exhaustive { list reveals several challenges that can be addressed through innovative educational strategies for teaching SPMs and fostering a more practical and immersive learning environment, bridging the gap between theoretical concepts and industrial applications. However, without clarity on the learning styles and preferences of SPMs, the selection of these techniques becomes a complex issue.

Regarding the educational methodology, Kolb [18] defined the concept of *learning* as the process through which knowledge is built by transforming experience: knowledge arises from the merging of grasping and reshaping experience. He introduced the experiential learning cycle (Fig. 1), a recursive process finely tuned to both the learning context and the subject under study [18].

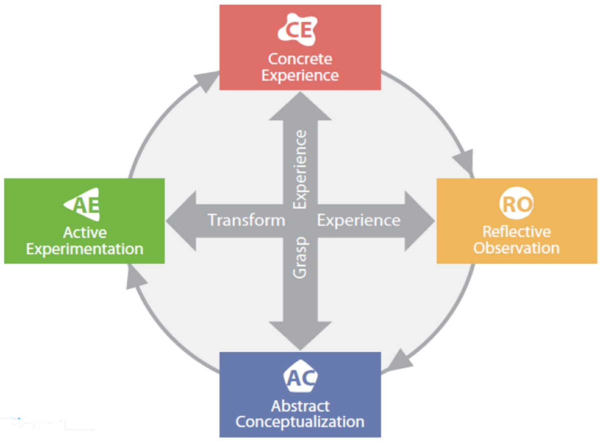

Figure 1. The experiential learning cycle

Learning styles delineate how individuals traverse the learning cycle, guided by their inclination towards four distinct learning modes [18]: experiencing (concrete experience, or CE), reflecting (reflective observation, or RO), thinking (abstract conceptualization, or AC), and acting (active experimentation, or AE). However, over time, empirical and clinical research has demonstrated that these initial four learning modes can be further elaborated into a nine-style typology [18] known as *Kolb's learning style inventory* (Fig. 2).

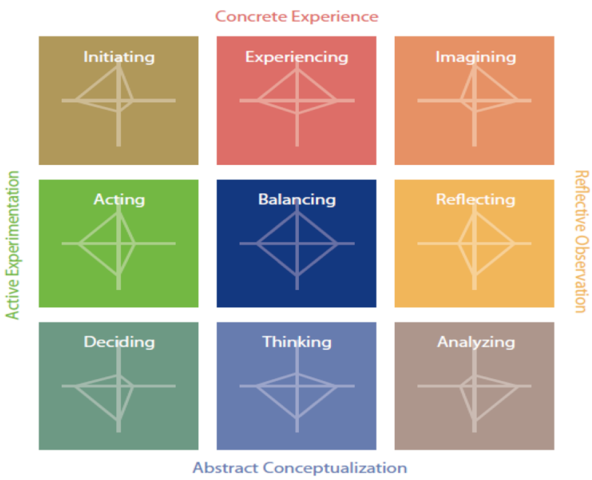

Figure 2. The learning styles in KLSI

KLSI expands upon the original model by establishing the nine learning modes detailed below.

- **Initiating.** Defined by the capacity to take action in response to experiences and situations, this style involves both AE and CE.
- **Experiencing.** Marked by a deep engagement with experiences to derive meaning, this style combines CE while balancing both AE and RO.
- **Imagining** is characterized by the ability to envision possibilities through observation and reflection on experiences, blending CE with RO.
- **Reflecting.** Distinguished by the ability to link experiences with ideas through extended reflection, this style integrates RO with both CE and AC.
- **Analyzing** is characterized by the ability to structure and systematize ideas through reflection, combining RO with AC.
- **Thinking.** Defined by the capacity for focused, abstract, and logical reasoning, this style uses AC while balancing both AE and RO.
- **Deciding.** Defined by the ability to use theoretical models and frameworks to make decisions and determine courses of action, this style combines AC with AE.
- **Acting.** Characterized by a strong drive for goal-oriented actions that integrate both people and tasks, this style emphasizes AE, with a balance of CE and AC.
- **Balancing.** Defined by adaptability, this style involves weighing the benefits of action *vs.* reflection, as well as experience *vs.* thinking. It balances all four learning modes: CE, AC, AE, and RO.

Considering the skills required and the conceptual model presented by KLSI, software engineering education (SEE) stands to benefit from identifying the predominant learning style among SPM practitioners. This approach can help to align instructional methods with the preferred learning styles, thereby enhancing skills development. Therefore, our objective and its corresponding research question are as follows:

Research objective. To identify the predominant learning styles among SPMs using KLSI and propose tailored educational strategies that align with these preferences. By understanding how SPMs learn, we aim to bridge the gap between theoretical knowledge and practical application, thereby enhancing the effectiveness of training programs in SEE.

Research question. In a given sample of SPMs, what are the common teaching and learning preferences?

Rationale. Understanding the learning and teaching preferences of SPMs allows educators to develop tailored activities and strategies that effectively meet unique needs and learning styles within a given practitioner group.

Why Kolb's model? Kolb's experiential learning theory (ELT) was chosen for this study due to its comprehensive framework, which bridges learning styles with practical application. This is essential for SEE. While other models (*e.g.*, VARK* or Honey-Mumford†) focus on specific aspects related to learning preferences |such as sensory modalities or adaptations of Kolb's framework | Kolb's model emphasizes a cyclical process of learning through experience, reflection, conceptualization, and experimentation. This iterative approach aligns closely with the dynamic and practical nature of software project management, where professionals must continuously adapt theoretical concepts to evolving project environments. Moreover, KLSI offers an empirically validated tool [18] to categorize learning preferences, providing a strong basis for designing educational strategies tailored to engineering roles.

Related work

The continuous evolution of software development techniques demands skilled project managers [1]. In higher education, graduate and post-graduate curriculum guides have been developed to meet industry demands, emphasizing the need for better software project management skills [6]. New teaching models based on professional certification within engineering education can improve the achievement of course objectives and the overall training of software engineering professionals [35]. Additionally, the use of e-learning platforms and digital communication channels can enhance the continuous improvement of project managers' competencies, reducing onboarding time and improving performance [2].

In the industry, SPMs must master both management and technical skills to effectively lead and control software development projects [17, 24]. A systematic review of SPME highlights the need for the continuous evaluation and improvement of teaching methods and tools to ensure quality education and meet industry demands [12]. In terms of teaching methods, serious games can effectively teach software engineering and project management concepts, engaging students in a dynamic and safe learning environment [6]. Iteratively refined courses that include evidence-based readings, quizzes, in-class activities, and ambitious projects can address common challenges in teaching software project management [25]. Additionally, tools like ProMES are used to train project managers on basic techniques such as CPM, PERT, and RACI, enhancing their understanding through pedagogical approaches [16]. Furthermore, project management software packages can reduce issues related to management and control in educational software projects [33].

In summary, the effective teaching of software project management necessitates a blend of methods and interactive learning tools. Despite this, there is limited evidence on the impact of learning styles on practitioners in SEE, pointing to a critical gap in enhancing educational strategies. While previous research has explored various aspects of SPME, most studies focus on general methodologies or specific pedagogical tools without addressing participants' individual learning preferences.

*The VARK model (visual, aural, read/write, kinesthetic) assesses four sensory modalities that people use to learn.

†The four different ways in which people prefer to learn that Honey and Mumford have identified relate to a different stage in the learning cycle. These are the Activist, the Reflector, the Theorist, and the Pragmatist. In this model, Mumford and Honey describe the learning styles as a continuum that one moves through over time.

For instance, [12] conducted a systematic review of teaching methods in project management education but did not examine the role of learning styles in their effectiveness. Similarly, [25] proposed an iterative course based on theoretical objectives but lacked adaptation to specific learning styles.

Our work advances this field by applying KLSI to identify and characterize the predominant learning style among SPMs. This allows designing evidence-based educational strategies that align with their preferences, incorporating both practical and theoretical approaches. Unlike studies such as [20], which highlight the absence of learning style integration in engineering education, our research incorporates learning preferences and teaching strategies to enhance SPM training programs.

Research method: survey

This section summarizes the survey employed as our research method, its implementation, its inclusion and exclusion criteria, its underlying assumptions, and the profile of its participants.

Kolb's learning style test survey

To guide our research, we drew upon insights from [29] and [13] regarding survey application and results analysis. Given the nature of our study, we utilized the KLSI test for data collection. This test comprises 12 sentence completion questions (Table 1), where participants rank provided suffixes on a scale of 1 to 4, with 4 indicating the highest preference.

Table 1: Kolb's test applied

PREFIX	SUFFIX
Q1. *When I learn...*	I prefer to rely on my sensations and feelings
	I prefer to look and pay attention
	I prefer to think about ideas
	I prefer to do things
Q2. *I learn best when...*	I trust my hunches and feelings
	I listen and observe carefully
	I trust my logical thoughts
	I work hard to get things done
Q3. *When I am learning...*	I have strong feelings and reactions
	I am reserved and calm
	I seek to reason about things that are happening
	I feel responsible for things
Q4. *I learn through...*	Feelings
	Observations
	Reasoning
	Actions
Q5. *When I learn...*	I am open to new experiences
	I take into account all related aspects
	I prefer to analyze things by breaking them down into their component parts
	I prefer to do things directly
Q6. *When I am learning...*	I am an intuitive person
	I am an observant person
	I am a logical person
	I am an active person
Q7. *I learn best through...*	Relationships with my peers
	Observation
	Rational theories
	The practice of the topics covered
Q8. *When I learn...*	I feel involved in the topics covered
	I take my time before acting
	I prefer theories and ideas
	I prefer to see the results through my own work
Q9. *I learn best when...*	I rely on my intuitions and feelings
	I rely on personal observations
	I take into account my own ideas about the subject matter
	I personally try out the task
Q10. *When I am learning...*	I am open-minded
	I am a reserved person
	I am a rational person
	I am a responsible person
Q11. *When I learn...*	I get involved
	I prefer to observe
	I prefer to evaluate things
	I prefer to take an active attitude
Q12. *I learn best when...*	I am receptive and open-minded
	I am careful
	I analyze ideas
	I am practical

Continued on next page

Table 1: Kolb's test applied (Continued)

The test structure facilitates the assessment of participants' inclinations toward each of the four learning modes and allows categorizing each individual into a specific learning style [18].

Inclusion/exclusion criteria

Our research established the following inclusion/exclusion criteria for the participants:

Inclusion criteria. To qualify for the study, the respondents had to meet the following criteria:

- Hold the position of SPM within the industry.
- Have no prior experience with the KLSI test.

Exclusion criteria. To minimize potential biases, individuals would be deemed ineligible for participation if they met any of the following criteria:

- Lack of proficiency in reading English or Spanish.
- Work directly with any of the researchers.

Assumptions. Our research was based on the following assumptions:

- **Assumption 1.** The KLSI test, designed for adults, applies to professionals without necessitating adjustments or modifications.
- **Assumption 2.** The sample will offer comprehensive insight into learning styles, thereby facilitating the identification of representative trends.

Test execution

For our research, the execution of the survey considered the following aspects:

Test administration. The test was conducted with voluntary participation and anonymously collected responses. Invitations were distributed to 83 individuals currently employed as SPMs through professional networks, inviting them to participate in the study. The participants were provided with a link to access.

Characterization of the survey sample. The test was administered over 60 days, from the second week of January 2024 to the first week of March 2024. Ultimately, a sample of 27 participants who met the criteria was obtained, representing individuals from Chile, Costa Rica, Argentina, Colombia, and Spain. From the total number of invitations sent, 27 individuals completed the survey, representing a response rate of 32.5%. The distribution of participants by country is as follows:

- **Chile:** eight participants (29.6%)
- **Costa Rica:** six participants (22.2%)
- **Argentina:** five participants (18.5%)
- **Colombia:** four participants (14.8%)
- **Spain:** four participants (14.8%)

This distribution reflects the participation rate by country, with Chile representing the largest proportion of the sample.

Results

This section presents the results of the applied survey, indicating the learning modes and characterizing the learning style of the SPMs. It provides appropriate teaching/learning strategies to serve as a baseline for educators and researchers in SEE.

Table 2. SPM sample { learning modes score

Experience	Total_CE	Total_RO	Total_AC	Total_AE
Junior	20	29	35	36
Mid-senior	25	34	31	30
Mid-senior	23	35	28	34
Senior	21	30	36	33
Senior	26	44	27	23
Senior	20	36	40	24
Senior	24	40	27	29
Senior	21	34	35	30
Senior	26	25	40	29
Senior	22	30	36	32
Senior	27	33	33	27
Senior	22	32	40	26
Senior	25	21	34	40
Senior	22	38	26	34
Senior	19	38	39	24
Senior	31	19	25	45
Senior	32	26	37	25
Senior	22	21	33	44
Senior	21	33	37	29
Senior	36	34	27	23
Senior	20	30	39	31
Senior	21	23	33	43
Senior	31	27	29	33
Senior	23	40	30	27
Senior	34	19	37	30
Senior	24	34	40	22
Senior	26	25	37	32

SPM sample and representativeness

The SPM group, consisting of 27 respondents, included 1 junior, 2 mid-senior, and 24 senior practitioners. The test results for each individual are presented in Table 2. To determine the validity of the mean as a representative measure of each learning mode for the sample, we employed the Student's t-test [31] and defined the following hypotheses:

$H_0 \rightarrow$ The mean of each learning mode is not representative of the SPM sample[‡].

$H_1 \rightarrow$ The mean of each learning mode is representative of the SPM sample.

According to Student's t-distribution table (two-tailed), with a significance level of 0.05 (corresponding to 95% confidence) and 26 degrees of freedom ($27 - 1 = 26$), the critical value for the sample is ± 2.056. Utilizing the scores from Table 2, and taking the median as our hypothetical population mean, Table 3 presents this reference value alongside the sample mean and the standard deviation.

Table 3. Mean, median, and standard deviation of the sample

	CE	RO	AC	AE
Mean	24.59	30.74	33.74	30.93
Median	23.00	32.00	35.00	30.00
Standard deviation	4.58	6.75	4.88	6.38

To determine the t-statistic value of each learning mode, the following formula is employed:

[‡]By *representative of the sample*, we imply that the mean accurately reflects the central tendency of the sample's learning modes.

$$t = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}}$$

where

- $\bar{x}$ represents the sample mean,
- μ represents the hypothetical population mean (median),
- s represents the sample standard deviation, and
- n represents the sample size.

The results of the t-statistic value for each mode are shown in Table 4.

Table 4. T-statistic value for each learning mode

Learning mode	t-statistic value
Concrete experience (CE)	1.80
Reflective observation (RO)	-0.97
Abstract conceptualization (AC)	-1.34
Active experimentation (AE)	0.75

Finally, since the statistical value of each learning mode falls within the acceptance interval determined by the critical value of Student's t-distribution (±2.056), the H_0 hypothesis is rejected, and H_1 is accepted. This indicates that the sample mean is representative of each learning mode in the sample.

Learning style of the SPMs

Based on the results of the Student's t-test, and considering the sample mean as a representative measure of the population for each learning mode, it can be stated that the AC mode shows the highest inclination, suggesting a preference for theoretical analysis. However, there is a balance between AE and RO, indicating that the SPMs also have a strong inclination towards the practical application of learning and towards considering different perspectives before taking action. CE indicates a preference { though less pronounced when compared to the other modes { for learning through practical experiences. Overall, while the modes are not entirely balanced, there is a notable presence in all four modes, leading SPMs to be categorized under the *thinking* learning style, as depicted in Figure 3.

The thinking learning style

The *thinking* learning style emphasizes AC while maintaining a balance between AE and RO. This style is characterized by a strong capacity for disciplined engagement in abstract reasoning, mathematics, and logic [18]. Individuals with the thinking style typically enjoy working with numbers and engaging in mental activities that require abstract reasoning and analytical skills. They often prefer to work with quantitative rather than qualitative information [18]. Moreover, they excel in planning and goal-setting, tend to express emotions in a controlled manner, and prefer precise and concise communication [18]. The learning strengths of individuals with the *thinking* style include logical analysis, rational decision-making, and proficiency in analyzing quantitative data.

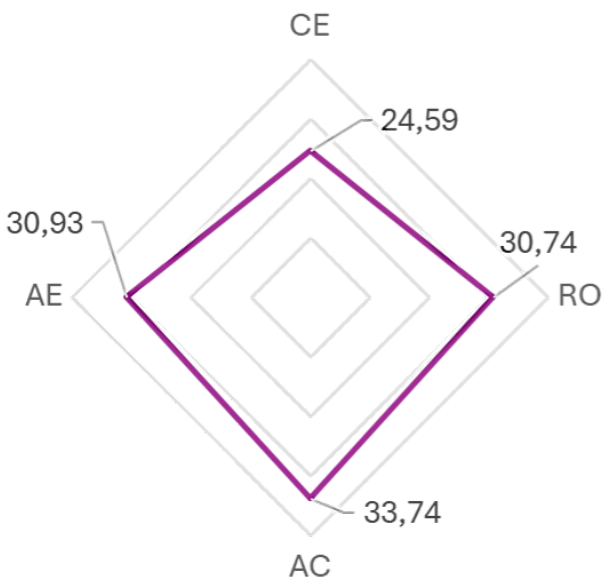

Figure 3. SPMs learning style characterization

Learning preferences and teaching strategies for SPMs

Individuals with the *thinking* style learn best in well-structured learning environments that feature clear directions and defined learning agendas. They thrive in settings where they can design experiments, manipulate data, or engage in abstract reasoning [18]. However, they typically prefer to work independently and require ample time to contemplate ideas thoroughly, which can pose challenges in collaborative settings and in remaining open to new ideas [18].

Learning preferences

This subsection explores the main learning preferences of the SPMs within the context of the *thinking* learning style from KLSI and its application in the software industry.

Analysis and reflection. SPMs tend to prefer detailed analysis and reflection on problems and solutions. To cater to this preference, consider the following:

- case study analysis,
- study of past project successes and failures, and
- reflective discussions on various software development approaches and methodologies [20].

Modeling and conceptualization. Creating models and conceptualizing abstract ideas are essential for SPMs in software processes. To meet these preferences, consider

- visualizing concepts using flowcharts and UML [19] and
- software process modeling using BPMN tools [32].

Problem-solving and critical thinking. SPMs often enjoy intellectual challenges and exercises that allow them to utilize their critical thinking and problem-solving skills. To cater to this preference, consider:

- complex case studies requiring deep analysis,
- problem-solving debates on controversies in the software industry [7], and
- practical exercises from the SPM perspective to identify and resolve software development issues.

Experimentation. SPMs often prefer learning through research and practical experimentation. To address this preference, consider

- practical projects for comparing methodologies and
- laboratory environments for experimenting with various tools and software development techniques [15].

Learning strategies

This subsection outlines the recommended teaching techniques/strategies for SPMs featuring the *thinking* learning style [18].

Problem-based learning (PBL). This technique involves presenting students with complex problems related to software development and guiding them through the problem-solving process. The expected learning outcome is to develop critical thinking and problem-solving skills by applying theoretical concepts in practical situations [23].

Collaborative learning. Given the learning challenges associated with the thinking style and the collaborative nature of an SPM's work, fostering collaboration among students through group projects and class discussions can be highly beneficial. The expected learning outcome involves sharing knowledge and experiences and fostering teamwork to collectively tackle complex challenges [14].

Experiential learning. A valuable strategy for SPMs includes gaining practical experience through projects and, ideally, internships in related industries. The expected learning outcome, particularly from internships, aims to apply theoretical knowledge in practical, unfamiliar settings, in addition to developing adaptability skills [8].

Case studies and simulations. Utilizing real case studies and simulations of software projects helps students to understand the complexities and challenges of software development in practical contexts. The expected learning outcome focuses on analyzing successful and failed cases in the software industry to derive lessons on best practices, as well as on the pitfalls to avoid [26].

Summary. Based on the identified learning styles of the sampled SPMs, Table 5 summarizes the key learning preferences observed, along with the teaching strategies recommended to enhance their learning experience, considering the learning mode to be strengthened. Furthermore, this study highlights the learning preferences of SPMs and proposes tailored educational strategies to optimize their development. Notably, PBL and collaborative learning emerge as particularly effective approaches for SPMs, given their inclination towards AC and AE. These strategies foster critical thinking, problem-solving, and teamwork, which are essential skills for effective project management in the software industry. Table 6 provides a summary of these strategies and their expected outcomes in terms of skills development. Based on the learning preferences identified herein, we recommend the integration of PBL and collaborative learning as core pedagogical strategies. These strategies align well with the learning style of SPMs, promoting the acquisition of key project management skills.

Experimental validation

To validate the effectiveness of the proposed learning strategies, we conducted an experimental application [13] within a postgraduate course on software project management. The aim was to assess how strategies such as PBL, collaborative learning, and case study analysis could enhance student engagement and learning. The experiment involved 16 students who voluntarily participated in the experience. These strategies were designed to align with the learning preferences identified through KLSI, particularly focusing on students who exhibited a preference for AE and RO. By integrating these strategies into the course, we aimed to engage students whose learning styles were most conducive to these interactive, collaborative, and hands-on approaches. The effectiveness of the learning strategies was explored throughout these sessions, allowing for an assessment of both engagement and learning outcomes.

Experimental setup

The experiment took place over four sessions in the postgraduate course. A total of 16 students voluntarily chose to participate in this experience, and they were randomly divided into two groups:

- Experimental group (eight students). These individuals engaged in learning activities based on the proposed strategies.
- Control group (eight students). These individuals participated in traditional lecture-based learning with no integration of the experimental strategies.

Session details

The experiment consisted of three main sessions, followed by a fourth session to gather feedback from the students.

1. **Session 1: problem-based learning (PBL)**
    - *Experimental group*. The students were given a real-world project failure scenario and worked in teams to identify the causes and propose recovery solutions.
    - *Control group*. The students attended a lecture on risk management and were assigned individual readings about the common causes of project failure.
2. **Session 2: collaborative learning**

Table 5. Summary of the SPMs' learning preferences and recommended pedagogical strategies

Learning mode	Recommended pedagogical strategy
Concrete experience	Practical projects, laboratory environments, experiments comparing methodologies
Reflective observation	Case study analysis, reflective discussions on project approaches and methodologies
Abstract conceptualization	Theoretical analysis, conceptual modeling tasks, problem-solving debates on software development
Active experimentation	Practical exercises to apply methodologies and real-time problem-solving in software development

Table 6. Key educational strategies and their expected outcomes

Educational strategy	Expected learning outcome
Problem-based learning (PBL)	Enhances critical thinking, problem-solving skills, and the ability to apply theoretical knowledge in practical settings.
Collaborative learning	Fosters teamwork, communication skills, and the ability to tackle complex problems through group discussions and shared knowledge.

- *Experimental group.* The students worked in pairs to develop a project plan for a new software product, including its scope, timeline, and resource management. They then presented their plans to the class for feedback.
- *Control group.* The students worked individually to create a project plan based on theoretical readings, which they then submitted for review.

3. **Session 3: case study analysis**
    - Experimental group. The students analyzed the case of a software project and discussed the factors that contributed to its success. They applied these lessons to their project plans developed in Session 2.
    - Control group. The students read a case study individually and summarized the key points. This was followed by a brief group discussion.
4. **Session 4: feedback and survey.** After the completion of the activities, all students completed a survey to express their opinions on the learning strategies used during the sessions. The results were then explained to the students in a follow-up session, where they discussed their experiences and provided further insights into their perceptions of the activities.

Survey and results

After completing the activities, all 16 students filled out a survey to provide their opinions on the learning strategies used during the sessions. The survey consisted of five questions designed to assess student engagement, satisfaction, and the effectiveness of the learning activities. The questions were:

1. **How engaged did you feel during the activities?**
    - 1 (Not engaged) to 5 (Very engaged)
2. **How useful did you find the learning activities for developing project management skills?**
    - 1 (Not useful) to 5 (Very useful)
3. **To what extent do you think the learning activities helped you understand project management concepts?**
    - 1 (Not at all) to 5 (A great deal)
4. **How confident are you in applying the strategies learned during the activities to real-world projects?**
    - 1 (Not confident) to 5 (Very confident)
5. **Overall, how satisfied are you with the learning activities in this course?**
    - 1 (Not satisfied) to 5 (Very satisfied)

The average survey results (Table 7) are divided into two groups: the experimental group and the control group.

The survey results indicate that the experimental group, which participated in the activities designed with PBL, collaborative learning, and case study analysis, reported significantly higher levels of engagement, usefulness, and satisfaction compared to the control group. The experimental group also showed greater confidence in applying the strategies learned during the course. In contrast, the control group, which followed traditional lecture-based learning, reported lower satisfaction and engagement levels. This suggests that the interactive and practical nature of the activities implemented in the experimental group had a more positive impact on their learning experience.

These results align with the learning preferences identified through KLSI in the previous study. The experimental group, which likely exhibited preferences for AE and RO (common traits for the *thinking* learning style), benefited from the hands-on, collaborative, and case study-based strategies. These strategies are well-suited for learners who prefer to engage in practical activities and analyze outcomes through reflection and collaboration. On the other hand, the control group, which received traditional lecture-based instruction, may not have fully engaged with their preferences, leading to lower levels of satisfaction and engagement.

Threats to validity and limitations

This section discusses the potential threats to the validity of our study and outlines how they were mitigated. We

Table 7. Survey results for the experimental and control groups

Question	Experimental group	Control group
Engagement level	4.625	2.250
Usefulness of learning activities for project management skills	4.750	3.125
Effectiveness in understanding project management concepts	4.875	2.625
Confidence in applying strategies to real-world projects	4.625	2.375
Overall satisfaction	4.875	2.375

followed the standard categories: conclusion, internal, construct, and external validity.

Conclusion validity

Conclusion validity examines whether the observed relationship between the treatment (KLSI) and the results (the identified learning styles and educational strategies) is statistically significant. The use of the Student's t-test, with a confidence level of 95%, ensures the robustness of the conclusions. While the sample size of 27 participants limits the detection of smaller effects, the statistical methods employed mitigate this threat and provide a solid foundation for the findings.

Internal validity

Internal validity aims to determine whether the relationship between the treatment and the outcome is causal. Potentially confounding variables, such as the participants' prior exposure to management training or cultural influences, were minimized by ensuring that the respondents had no prior experience with KLSI. Additionally, the consistency in the responses across participants supports the causal interpretation of the findings.

Construct validity

In this case, construct validity focused on whether KLSI accurately captured the theoretical constructs it aimed to measure. The KLSI is an empirically validated tool for identifying learning styles in adults, making it suitable for this study. Although the tool was not specifically tailored to SPMs, its broad applicability ensures reliable measurement.

External validity

External validity examines the extent to which the results of this experimental study can be generalized beyond the specific sample to other contexts, populations, or learning environments. In this experiment, the learning strategies, *i.e.*, PBL, collaborative learning, and case study analysis, were tested in a postgraduate SPM course with 16 volunteers. While this experiment was conducted in a controlled setting with a specific group of postgraduate students, the strategies used are expected to have broader applicability in similar educational contexts, particularly in learners whose preferences align with active and experiential learning styles, as identified through KLSI.

The experimental design, which incorporated interactive, collaborative, and hands-on activities, was well-suited for students with a preference for AE and RO. Given that these strategies are grounded in active learning principles, they can likely be applied in other postgraduate or professional development programs in SPM and other related fields, particularly those focused on developing both technical and soft skills.

However, the study's external validity is somewhat limited by the specific demographic of the sample, which comprised only 16 students from a particular academic background and geographic region. Although the diverse backgrounds and professional experiences of the participants allowed for a broad exploration of the strategies' effectiveness, future studies could enhance generalizability by including larger samples that also stem from different academic settings or industries. For example, expanding the sample to include students from other engineering disciplines or professionals with varying levels of experience in project management could provide further insights into the applicability of these strategies in different contexts. Additionally, replicating the experiment in other cultural or geographic regions could help to determine whether these strategies are equally effective across diverse educational systems.

The successful application of the proposed strategies in this experimental context suggests that they could be adapted and implemented in various educational and professional development settings, but further, more diverse research is needed to fully assess their applicability in other environments.

Limitations

While this study provides valuable insights, certain limitations should be acknowledged:

- *Sample size*. The relatively small sample size limits the detection of subtler effects. However, the identified patterns are consistent and meaningful.
- *Geographical scope*. The participants were predominantly from Spanish-speaking countries, which may affect applicability to other cultural contexts.
- *Self-reported data*. The reliance on self-assessment in KLSI may introduce minor biases, although the tool's design minimizes this risk.

By addressing these threats and limitations, this study provides a robust foundation for understanding the learning styles of SPMs and offers an adaptable framework for diverse educational contexts.

Discussion

This article explored the use of Kolb's test to determine the learning style that best represents a sample of SPMs according to KLSI [18]. Our research revealed that SPMs tend to have a strong preference for theoretical analysis and the practical application of concepts, with a particular inclination towards AC and AE, as well as a balance between RO and CE. This suggests that this group of SPMs leans towards the *thinking* learning style. A statistical analysis showed that this result is representative of the sample. Thus, it is understood that SPMs consider multiple perspectives before making decisions [2], implying the need for an educational approach that combines theoretical and practical methods [16, 33].

The findings of this study on SPMs' learning styles, particularly their inclination towards the *thinking* learning style, align with the specialized literature, which emphasizes the importance of both technical and management skills in effective project management [17, 24]. The emphasis on AC as a dominant learning mode among SPMs corroborates the notion that project managers benefit from strong analytical and problem-solving skills, as supported by studies such as [12] and [35].

Moreover, our research expands the current understanding by incorporating KLSI, highlighting a specific need for tailored educational strategies that address the unique learning preferences of SPMs. This finding aligns with the work of [17], which underscores the necessity of continuous improvement in teaching methods to meet industry demands [25]. Additionally, the balanced representation of RO and AE in our sample indicates a versatile learning approach, which is important for adapting to the dynamic nature of software project environments [6].

On the other hand, and contrary to the limited evidence on the consideration of learning styles in SEE [20], our results provide empirical support for the integration of learning style-based strategies. This is particularly relevant for enhancing the pedagogical approaches used in SPM training programs, as suggested by [16]. Our findings suggest that incorporating varied teaching methodologies, such as PBL and collaborative learning, can better cater to the diverse learning preferences observed among SPMs, thus potentially improving the efficacy of SEE programs [33].

Furthermore, the importance of practical experiences and hands-on learning, as indicated by the significant scores in the AE mode, aligns with previous research advocating for experiential learning in SEE [15]. This study not only reaffirms the value of such approaches but also emphasizes the need for educational curricula to evolve continually to accommodate the changing requirements of the software industry [12].

Addressing this gap could lead to optimized educational strategies and teaching methods adapted to the specific needs of SPMs [16, 33]. In this vein, we suggested a set of strategies that align with the identified learning preferences. These strategies include PBL, collaborative learning, experiential learning, and case studies. Their effectiveness was experimentally validated, with the experimental group achieving higher levels of engagement (4.625 *vs.* 2.250), perceived usefulness (4.750 *vs.* 3.125), and overall satisfaction (4.875 *vs.* 2.375) compared to the control group. These results support the implementation of these techniques to foster a more dynamic and adaptable learning environment that better responds to the current challenges of the software industry [1].

In summary, this research offers insights that can enhance the design and implementation of SEE programs. The alignment of our findings with the existing literature supports the need for an interdisciplinary approach that integrates both technical and managerial training, tailored to the specific learning preferences of SPMs. Future research could further explore the impact of these educational strategies on the performance and career development of SPMs, thereby contributing to a more robust and responsive educational framework in software project management.

Conclusions

In this article, Kolb's test was used to identify the predominant learning styles in a group of 27 software project managers based on Kolb's learning style inventory. The results revealed a strong preference for theoretical analysis and the practical application of concepts, with a particular inclination towards abstract conceptualization and active experimentation. Additionally, a balance was noticed between reflective observation and concrete experience, suggesting that these SPMs lean towards the *thinking* learning style.

A statistical analysis, conducted using Student's t-test, demonstrated that the results are representative of the sample with a 95% confidence interval. This validates the robustness of our conclusions and suggests that the results could be generalized (with a larger sample) to a broader population of SPMs, at least within Spanish-speaking contexts.

Moreover, the geographical diversity of the participants reinforces the reproducibility of our findings, indicating that the identified learning preferences are not significantly influenced by the geographical location of the SPMs. The use of neutral prefixes in the KLSI test also helped to mitigate potential biases in the responses, ensuring the objectivity of the results.

Based on these findings, it could be argued that an educational approach combining theoretical and practical methods can improve the training of SPMs by aligning with their learning preferences. In this vein, strategies such as problem-based learning, collaborative learning, experiential learning, and the use of case studies and simulations are recommended. Implementing these strategies will not only improve the effectiveness of SPM training but also foster a more dynamic and adaptable learning environment that is better able to respond to the current challenges of the software industry.

In summary, this study not only provides a detailed insight into the learning preferences of SPMs; it also offers a practical framework for optimizing educational strategies in software project management. The findings are statistically significant and reproducible, underscoring the relevance and applicability of the results in educational and professional practice.

Future Work

For future work, we plan to expand the sample size and include a more diverse group of SPMs to validate the generalizability of the learning preferences identified in this study. Additionally, we aim to conduct intervention-based research to implement and evaluate specific educational strategies such as PBL and collaborative learning, providing empirical evidence of their effectiveness in enhancing SPM training and project management performance, with a particular focus on their integration into frameworks like PMBOK or Agile.

Acknowledgements

This work has been partially supported by Universidad Finis Terrae through the "Laboratorio de Investigación Avanzada en Ciencias de Datos en Derecho" - LIACDD UFT.

Author contributions

All authors have contributed to the current work, which constitutes part of Mauricio Hidalgo's doctoral research work, supervised by Dr. Astudillo and Dr. Castro.

Conflicts of interest

The authors have no competing interests to declare that are relevant to the content of this article.

Data availability

All the research data is provided in the article.

Statement on Artificial Intelligence (AI)

During the elaboration of this work, the authors used ChatGPT to improve the writing. After using this tool, the authors reviewed and edited the content as necessary and took full responsibility for the content of the publication.

References

[1] S. Al-Saqqa, S. Sawalha, and H. AbdelNabi, "Agile software development: Methodologies and trends," *Int. J. Interact. Mobile Tech.*, vol. 14, no. 11, pp. 246{270, 2020. https://doi.org/10.3991/ijim.v14i11.13269

[2] S. Atanasijevic, M. Zahar, D. Rancic, T. Atanasijevic, and M. Đorđević, "Creating an educational framework for project managers at a software company: A sample approach," in *Proc. Int. Sci. Conf. - Sinteza 2023*, 2023, pp. 199{205. https://doi.org/10.15308/Sinteza-2023-199-205

[3] S. Atanasijevic, M. Zahar, D. Rančić, I. Vulić, and T. Atanasijevic, "Enabling digital growth through continuous education of project managers: A framework for collaborative, complementary, sustained, and simultaneous learning in software engineering organizations," *Vojnotehnicki Glasnik*, vol. 71, no. 4, pp. 1172{1197, 2023. https://scindeks-clanci.ceon.rs/data/ipdf/0042-8469/2023/0042-84692304172A.pdf

[4] K. Ayas, "Learning through projects: Meeting the implementation challenge," *J. Eur. Ind. Train.*, vol. 22, no. 3, pp. 89{98, 1998.

[5] C. Boiangiu, A. C. Firculescu, and I. Bucur, "Teaching software project management: The independent approach," *Romanian Economic Business Review*, vol. 10, no. 1, pp. 11{22, 2016. https://ideas.repec.org/a/rau/journl/v10y2016i1p11-22.html

[6] C. Caulfield, D. Veal, and S. Maj, "Teaching software engineering project management { A novel approach for software engineering programs," *Math. Models Methods Appl. Sci.*, vol. 5, art. 87, 2011. https://doi.org/10.5539/mas.v5n5p87

[7] P. Chen and Y.-C. Chan, "Enhancing creative problem solving in postgraduate courses of education management using project-based learning," *Int. J. High. Educ.*, vol. 10, no. 6, art. 11, 2021. https://doi.org/10.5430/IJHE.V10N6P11

[8] S. Christov and M. E. Hoffman, "Experiential learning of software project management and software development via course collaboration," in *Proc. 50th ACM Tech. Symp. Comput. Sci. Educ.*, 2019, pp. 160{166. https://doi.org/10.1145/3287324.3287457

[9] A. Davis, "Fifteen principles of software engineering," *IEEE Softw.*, vol. 11, pp. 94{96, 1994.

[10] A. Ellahi, Y. Javed, M. F. Jan, and Z. Sultan, "Determining the effect of software project managers' skills on work performance," *Int. J. Inf. Technol. Proj. Manag.*, vol. 15, no. 1, pp. 1-20, 2023. http://dx.doi.org/10.4018/IJITPM.333620

[11] R. Fairley, *Managing and leading software projects*. Hoboken, NJ, USA: Wiley, 2009.

[12] M. Farooq, U. Omer, and R. Tahseen, "Software project management education: A systematic review," *J. Inf. Syst. Oper. Manag.*, vol. 9, no. 3, pp. 102{119, 2021. http://dx.doi.org/10.21015/vtse.v9i3.702

[13] M. Felderer and G. H. Travassos, "Contemporary empirical methods in software engineering," *Contemp. Empir. Methods Softw. Eng.*, 2020. [Online]. Available: https://api.semanticscholar.org/CorpusID:221346139

[14] R. Garcia, C. Treude, and A. Valentine, "Application of collaborative learning paradigms within software engineering education: A systematic mapping study," in *Proc. 55th ACM Tech. Symp. Comput. Sci. Educ.*, Portland, OR, USA, 2024, pp. 366{372. https://doi.org/10.1145/3626252.3630780

[15] G. Gonçalves, R. Meneses, J. Faria, and R. M. Vidal, "A living lab for professional skills development in software engineering management at U.Porto," in *Proc. 2020 IEEE Global Eng. Educ. Conf. (EDUCON)*, 2020, pp. 1079{1085. https://doi.org/10.1109/EDUCON45650.2020.9125099

[16] G. Gregoriou, K. Kirytopoulos, and C. Kyriklidis, "Project management educational software (ProMES)," *Comput. Appl. Eng. Educ.*, vol. 21, pp. 46{59, 2013. https://doi.org/10.1002/cae.20450

[17] J. Jurison, "Software project management: The manager's view," *Commun. Assoc. Inf. Syst.*, vol. 2, art. 17, 1999.

[18] D. Kolb and A. Kolb, *The Kolb Learning Style Inventory 4.0: Guide to Theory, Psychometrics, Research & Applications*, 2013. [Online]. Available: https://learningfromexperience.com/research-library/the-kolb-learning-style-inventory-4-0/

[19] S. Kumari, "Visual modeling: 'Unlocking ideas and enhancing understanding: The power of visual modeling,'" *Int. J. Eng. Technol.*, vol. 12, no. 2, pp. 20{25, 2023. https://doi.org/10.14419/ijet.v12i2.32334

[20] M. Mantyla, M. Jørgensen, P. Ralph, and H. Erdogmus, "Guest editorial for special section on success and failure in software engineering," *Empir. Softw. Eng.*, vol. 22, pp. 2281{2297, 2017. https://doi.org/10.1007/s10664-017-9505-5

[21] A. Moreno, M. I. Sánchez Segura, F. Medina-Domínguez, L. Peters, and J. Araujo, "Enriching traditional software engineering curricula with software project management knowledge," in *Proc. 2016 IEEE/ACM 38th Int. Conf. Softw. Eng. Companion (ICSE-C)*, 2016, pp. 404{411. https://ieeexplore.ieee.org/document/7883326

[22] S. H. Ow, "Improving soft skills of university students through software development team projects," *Asian Soc. Sci.*, vol. 4, art. 135, 2009.

[23] B. Pérez and A. Rubio, "A project-based learning approach for enhancing learning skills and motivation in software engineering," in *Proc. 51st ACM Tech. Symp. Comput. Sci. Educ.*, 2020, pp. 309{315. https://doi.org/10.1145/3328778.3366891

[24] L. Peters and A. Moreno, "Educating software engineering managers - revisited: What software project managers need to know today," in *Proc. 2015 IEEE/ACM 37th IEEE Int. Conf. Softw. Eng.*, vol. 2, 2015, pp. 353{359. https://doi.org/10.1109/ICSE.2015.168

[25] P. Ralph, "Re-imagining a course in software project management," in *Proc. 2018 IEEE/ACM 40th Int. Conf. Softw. Eng. Softw. Eng. Educ. Train. (ICSE-SEET)*, 2018, pp. 116{125. https://doi.org/10.1145/3183377.3183379

[26] A. H. Reed and M. Angolia, eds., *The value of simulation for learning project management*. Hershey, PA, USA: IGI Global Scientific Publishing, 2021. https://doi.org/10.4018/978-1-5225-3471-6.CH002

[27] G. Ruhe and C. Wohlin, *Software project management in a changing world*. Berlin, Germany: Springer, 2014.

[28] W. Scacchi, "Managing software engineering projects: A social analysis," *IEEE Trans. Softw. Eng.*, vol. SE-10, no. 1, pp. 49{59, 1984. https://doi.org/10.1109/TSE.1984.5010198

[29] M. Shaw, "Software engineering education: A roadmap," in *Proc. Conf. The Future of Software Engineering*, 2000, pp. 371{380.

[30] A. Sukhoo, A. Barnard, M. Eloff, J. Van der Poll, and M. Motah, "Accommodating soft skills in software project management," *Issues Inform. Sci. Inf. Technol.*, vol. 2, pp. 691{703, 2005. https://doi.org/10.28945/860

[31] H. W. Thompson, R. Mera, and C. Prasad, "A description of the appropriate use of Student's t-test," *Nut. Neurosci.*, vol. 1, no. 2, pp. 165{172, 1998.

[32] O. L. Vega-Márquez, J. Chavarriaga, M. Linares-Vásquez, and M. E. Sánchez, "Requirements comprehension using BPMN: An empirical study," in *Empirical Studies on the Development of Executable Business Processes*, 2019. https://doi.org/10.1007/978-3-030-17666-2_5

[33] V. Stiehl, M. Danei, J. Elliott, M. Heiler, and T. Kerwien, "Effectively and efficiently implementing complex business processes: A case study," in *Empirical studies on the development of executable business processes*, D. Lubke and C. Pautasso, Eds. Cham, Switzerland: Springer, 2019, pp. 33{57. https://doi.org/10.1007/978-3-030-17666-2_3

[34] B. Wu, "Modeling software maturity: A knowledge accumulation and continuous improvement approach," in *2012 3rd Int. Conf. Intell. Cont. Info. Proc.*, 2012, pp. 739{743.

[35] H. Zhou, Y. Zhu, J. Wan, and Q. Wang, "Exploration of teaching mode of software project management based on engineering education professional certification," *J. Educ. Human. Soc. Sci.*, vol. 6, pp. 160-164, 2022. https://doi.org/10.54097/ehss.v6i.4418