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Beyond YouTube Tutorials: How Online Communities and Failure Experiences Shape Digital Engineering Skill Development among Aviation Communication System Technicians

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ABSTRACT

Digital transformation has reshaped how aviation technicians acquire knowledge, with YouTube and online professional communities supporting digital competency development. However, their effectiveness in enhancing digital skill mastery remains insufficiently understood. This study examines the effects of YouTube-Based Learning, Online Community Engagement, Learning from Failure, and Self-Regulated Learning on Digital Skill Mastery among aviation data communication system technicians. A cross-sectional survey involved 100 technicians across seven aviation organizations in Indonesia. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). Results show that Online Community Engagement enhances Learning from Failure and Self-Regulated Learning, while Learning from Failure positively influences Self-Regulated Learning. Self-Regulated Learning is the only significant direct predictor of Digital Skill Mastery and mediates the relationship between Learning from Failure and Digital Skill Mastery. These findings show that aviation technical skills can be developed through reflective and self-regulated learning. This study highlights the importance of integrating community-based learning, reflective practice, and self-regulated learning into aviation technician training programs.

1. INTRODUCTION

Digital transformation has fundamentally reshaped the way technicians acquire and continuously update their professional competencies in the workplace. Whereas technical competency development was previously dominated by formal training, technical manuals, and structured certification programs, learning has increasingly shifted toward a more flexible, open, and needs-driven digital learning ecosystem.(Kyndt & Baert, 2022) Technicians are no longer solely dependent on instructors or training institutions to acquire new knowledge; instead, they actively utilize a wide range of digital learning resources, including video tutorials, discussion forums, professional communities, online documentation, and knowledge-sharing platforms (Margaryan, 2024). This transformation reflects a shift from a centralized training paradigm toward self-directed and workplace learning that occurs continuously throughout professional practice. Within increasingly digitalized work environments, the ability to learn autonomously and adapt to technological change has become as essential as mastering technical skills themselves (Feldman-Maggor, 2024) (Broadbent et al., 2021). Recent studies further suggest that digital environments and communities of practice play a pivotal role in supporting continuous professional learning, workplace skill development, and the construction of knowledge that is directly relevant to authentic work demands (Tummons & Tummons, 2025).

The rapid advancement of digital technologies has established YouTube as one of the most widely utilized learning resources for acquiring technical and professional skills. Unlike conventional learning materials that primarily rely on textual explanations, YouTube enables learners to access visual demonstrations, procedural simulations, and step-by-step explanations that can be studied independently according to individual learning needs (Mayer, 2021). These characteristics make YouTube particularly valuable in technical education because it facilitates learners' understanding of complex operational processes through direct visualization. In the context of professional learning, instructional videos also support the concept of just-in-time learning, whereby individuals seek learning resources precisely when confronted with specific work-related tasks or technical problems. Previous research has demonstrated that YouTube-based instructional videos can enhance conceptual understanding, procedural competence, learning motivation, and flexibility in acquiring new knowledge. Furthermore, the platform's accessibility, diversity of available content, and ability to revisit learning materials at any time have positioned YouTube as an integral component of the informal learning ecosystem and professional competency development in the digital era (Noetel et al., 2021). Thus, YouTube can serve as a self-learning resource for technicians who want to gain technical knowledge efficiently and independently without participating in structured formal training programs (Mayer, 2021; Feldman-Maggor, 2024).

Despite its widespread adoption as a technical learning resource, several studies have highlighted the limitations of YouTube in supporting the development of professional competencies that require troubleshooting abilities, contextual decision-making, and complex problem-solving skills (Greeves, 2024). Instructional videos are made to show procedures, so they focus more on transferring procedural knowledge rather than the cognitive processes needed when dealing with system failures, operational errors, or less-than-ideal working conditions. Moreover, the quality of YouTube content varies considerably due to the absence of standardized academic quality assurance mechanisms, requiring learners to independently evaluate the validity and relevance of the information they consume. Research has also shown that although instructional videos are effective

in explaining concepts and procedures, they are less capable of facilitating learning processes that require interaction, feedback, reflection, and discussion of authentic workplace problems (Kohler & Dietrich, 2021). In safety-critical technical domains such as aeronautical data communication systems, technicians frequently encounter system malfunctions, operational anomalies, and unexpected errors that are rarely addressed in tutorial videos (Keith & Frese, 2023). Consequently, a substantial gap exists between the procedural knowledge acquired through instructional videos and the practical knowledge required to resolve real-world technical problems encountered in professional practice (Veith et al., 2024). This gap suggests that digital technical competence cannot be adequately explained solely through the consumption of video-based learning resources but instead requires complementary learning environments that facilitate troubleshooting experiences, reflection on failures, and the acquisition of richer contextual knowledge (Greeves, 2024).

The limitations of video-based learning in addressing authentic workplace challenges have encouraged professionals to seek additional learning support through online communities. Within complex work environments, online communities function not merely as platforms for information exchange but also as collaborative spaces where members share experiences, discuss technical issues, and collectively develop solutions grounded in real-world practice. This perspective is consistent with the theory of Communities of Practice, which posits that professional learning emerges through active participation in communities that share common goals, language, and professional practices. Numerous studies have demonstrated that online communities effectively facilitate adult learning, professional competency development, and the construction of work-relevant knowledge by providing forms of social interaction that are absent from one-way learning resources such as instructional videos. Through discussions, question-and-answer interactions, and collaborative problem-solving, community members gain access to collective experiences that extend far beyond individual knowledge and expertise (Abedini et al., 2024).

More importantly, online communities serve as a primary mechanism for exchanging tacit knowledge, namely practical knowledge acquired through professional experience that is inherently difficult to formalize or document. Unlike explicit knowledge, which can be effectively communicated through manuals or instructional materials, tacit knowledge is often manifested in troubleshooting experiences, technical intuition, decision-making strategies, and lessons learned from operational failures. Previous research has demonstrated that professional online communities effectively support the sharing of tacit knowledge through case discussions, collaborative problem-solving, and experience exchange among practitioners. In the context of aeronautical data communication system technicians, information concerning the root causes of system failures, undocumented system configurations, or practical solutions to operational anomalies is often more readily obtained through community interactions than through official documentation or tutorial videos. Consequently, online communities play a critical role in transforming individual experiences into collective knowledge that can be leveraged by other members of the professional community (Buunk & Smith, 2018)(Ribeiro, 2021).

Self-regulated learning (SRL) is relevant to aviation data communication technicians because their work requires continuous learning, independent problem solving, and adaptation to unfamiliar technical situations. Technicians must identify learning needs, seek relevant information, evaluate solutions, and reflect on their effectiveness. Thus, SRL provides an important lens for understanding how technicians transform informal learning experiences into professional technical competence.

Although previous studies have examined video-based learning, self-directed learning, and online communities as separate sources of learning, limited attention has been paid to how failure-related experiences shared within professional online communities are transformed into learning processes that contribute to the development of complex digital technical skills among aviation technicians. More specifically, the literature has yet to sufficiently examine whether and how online community engagement facilitates learning from failure, which subsequently stimulates self-regulated learning and, in turn, contributes to technical skill mastery. Addressing this gap, the present study advances an integrated theoretical perspective by empirically testing a previously underexamined sequential mediational pathway from online community engagement through learning from failure and self-regulated learning to digital skill mastery. Rather than proposing a new standalone theory, the study contributes a theoretically grounded mechanism that explains how socially shared failure experiences can be transformed into individual learning regulation and ultimately into professional technical competence. This perspective extends existing understandings of digital learning beyond content consumption by positioning online communities as social environments in which experiential knowledge and failure-related experiences can be converted into self-regulated learning and skill development. From a practical perspective, the findings are expected to provide empirical evidence for aviation organizations in designing competency development strategies that extend beyond formal training by integrating professional communities and experience-based learning into a sustainable workplace learning ecosystem.

2. METHODS

This study employed a quantitative research approach using a cross-sectional survey design to examine the relationships among YouTube-Based Learning (YBL), Online Community Engagement (OCE), Learning from Failure (LFF), Self-Regulated Learning (SRL), and Digital Skill Mastery (DSM) among aviation data communication technicians. A cross-sectional survey was considered appropriate because the study aimed to test a theoretically grounded structural model using data collected from respondents at a single point in time (Creswell, 2023).

Summary of Research Model

The proposed research model integrates four complementary theoretical perspectives: Multimedia Learning Theory (Mayer), Communities of Practice (Lave & Wenger), Experiential and Error-Based Learning (Kolb; Frese & Keith), and Self-Regulated Learning Theory (Zimmerman). The model posits that YouTube-Based Learning and Online Community Engagement may be associated with Digital Skill Mastery both directly and indirectly through Learning from Failure and Self-Regulated Learning.

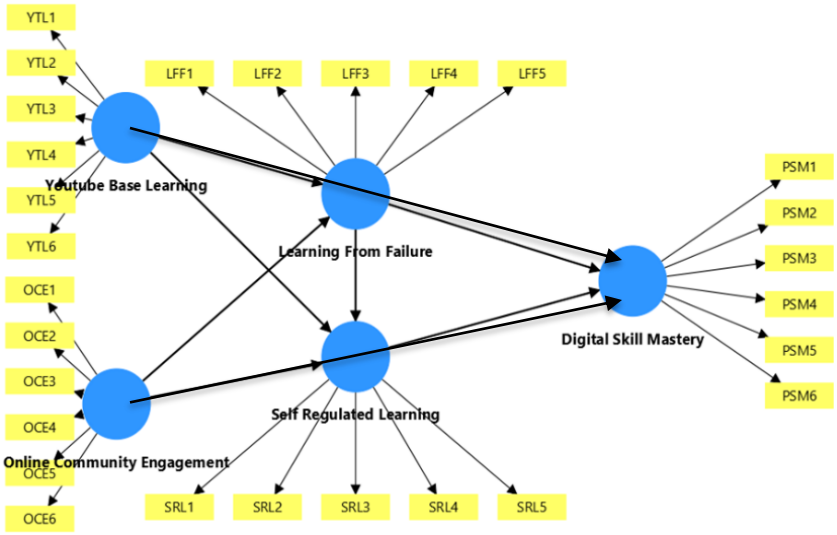


Figure 1. Research Model

Accordingly, the conceptual framework generates nine structural hypotheses (H1–H9) to be empirically tested using Partial Least Squares Structural Equation Modeling (PLS-SEM), with Digital Skill Mastery serving as the primary endogenous construct and Learning from Failure and Self-Regulated Learning functioning as mediating variables.

Participants

The target population consisted of aviation data communication technicians employed by organizations responsible for aviation communication and navigation systems and airport operators. These professionals routinely maintain, troubleshoot, and operate safety-critical communication systems while engaging in continuous informal learning through digital resources.

Data were collected using an online questionnaire distributed through professional communication channels and technician communities. A total of 100 valid responses from individuals across seven aviation organizations or companies were included in the analysis. Participants were recruited using a non-probability sampling approach, and only complete and usable responses were analyzed. Because information on non-respondents was not available for comparison, potential non-response bias cannot be ruled out.. Respondents had practical experience in aviation digital engineering and regularly used online learning resources such as YouTube tutorials, technical forums, and professional online communities to support their work-related learning.

The minimum sample size was determined using an a priori power analysis in G*Power. The most complex endogenous construct in the proposed model, Digital Skill in Aviation Mastery, is predicted by four constructs: Online Community Engagement, Learning from Failure, Self-Regulated Learning, and YouTube-Based Learning. Assuming a medium effect size (f^2 = 0.15), a significance level of α = 0.05, and statistical power of 0.80, the required minimum sample size for a multiple regression model with four predictors is 85 respondents. Considering the research objective and the characteristics of the proposed model, this sample (n=100) was considered adequate for Partial Least Squares Structural Equation Modeling (PLS-SEM), which is appropriate for prediction-oriented studies involving multiple latent constructs and relatively moderate sample sizes (Hair et al., 2022; Sarstedt et al., 2021). Although PLS-SEM can accommodate relatively small samples, the adequacy of the sample size (n = 100) for the five-construct, 28-item model should be interpreted cautiously.

Accordingly, the sample size is acknowledged as a methodological limitation, and the findings should be interpreted with consideration of the study's sample size and statistical power.

Instrument Development

Data were collected using a 28-item questionnaire comprising five reflective constructs: YouTube-Based Learning (YBL; 5 items), Online Community Engagement (OCE; 6 items), Learning from Failure (LFF; 5 items), Self-Regulated Learning (SRL; 6 items), and Digital Skill Mastery (DSM; 6 items). All items were measured on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Items for YBL, OCE, LFF, and SRL were adapted and contextualized from established literature on digital/video-based learning, online learning communities, learning from errors/failure, and self-regulated learning, respectively. The items were adjusted to reflect informal workplace learning and the specific activities of aviation data communication technicians. In contrast, the Digital Skill Mastery (DSM) items were developed specifically for this study to capture two complementary dimensions of aviation digital engineering competence: technical competence and troubleshooting capability. This approach was adopted because no single existing measurement scale was identified as directly encompassing both dimensions within the specific context of aviation communication systems. The newly developed items were therefore designed to reflect the technical and problem-solving demands of the study context.

Content validity was assessed through expert judgment involving two specialists in educational technology and aviation digital engineering, who independently evaluated the relevance, clarity, and contextual appropriateness of the 28 items for Indonesian aviation data communication technicians. Item-level and scale-level content validity were examined using the Item-Level Content Validity Index (I-CVI), Scale-Level Content Validity Index (S-CVI/Ave and S-CVI/UA), and modified kappa coefficients.

Data Analysis Technique

The proposed research model was analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4. PLS-SEM was selected because the study aimed to examine a prediction-oriented model involving multiple latent constructs and mediation effects rather than confirming an established covariance structure. Furthermore, PLS-SEM performs well with relatively moderate sample sizes and does not require strict multivariate normality assumptions (Hair et al., 2022).

The analysis followed the two-stage procedure recommended by Hair et al. (2022). In the first stage, the measurement model was evaluated by assessing indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. Indicator reliability was assessed through outer loadings (>0.70), while internal consistency was evaluated using Cronbach's alpha and Composite Reliability (>0.70). Convergent validity was examined through Average Variance Extracted (AVE >0.50). Discriminant validity was assessed using the heterotrait–monotrait ratio (HTMT) and the Fornell–Larcker criterion to determine whether the study constructs were empirically distinct from one another. The HTMT criterion evaluates the ratio of correlations between indicators of different constructs to correlations between indicators of the same construct. HTMT values below 0.85 indicate discriminant validity under the more conservative criterion, although a threshold of 0.90 may be acceptable for conceptually related constructs. In addition, the Fornell–Larcker criterion requires the square root of the average variance extracted (AVE) for each construct to exceed its correlations with all other constructs.

Collinearity was assessed using inner Variance Inflation Factor (VIF) values for the predictor constructs of each endogenous construct. VIF values below 5.00 were considered indicative of the absence of critical multicollinearity, while values below 3.00 were interpreted as indicating a more conservative level of collinearity. In addition, because all constructs were measured using self-report questionnaire data obtained from a single respondent source, a full-collinearity assessment was conducted as a supplementary diagnostic for potential common method bias (CMB). In this assessment, each latent construct was regressed against all other constructs in the model, and the resulting full-collinearity VIF values were examined. Values below 3.30 were interpreted as indicating that common method variance was unlikely to constitute a substantial threat to the structural estimates. These diagnostics were used to determine whether excessive predictor overlap or common method variance could substantially affect the observed structural relationships.

3. RESULTS

A total of 100 respondents were included in the analysis, consisting of aeronautical data communication system technicians from various institutions. The distribution of respondents across the participating institutions is presented as follows.

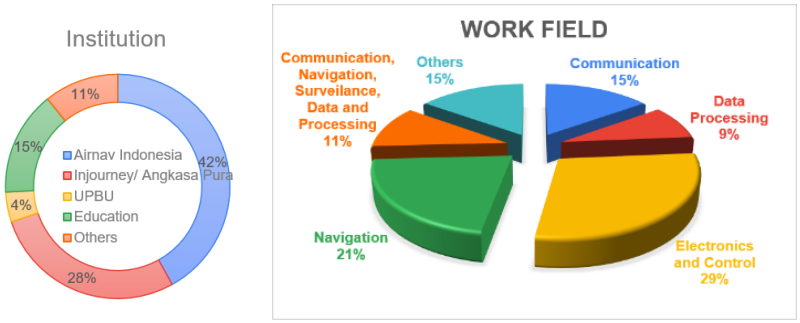


Figure 2. Institution and Work Field Participation

The results indicate that the respondents were relatively evenly distributed across various aviation service organizations; however, all participants belonged to the professional group of aeronautical communication and navigation technicians.

Measurement Model (Outer Model) Assessment

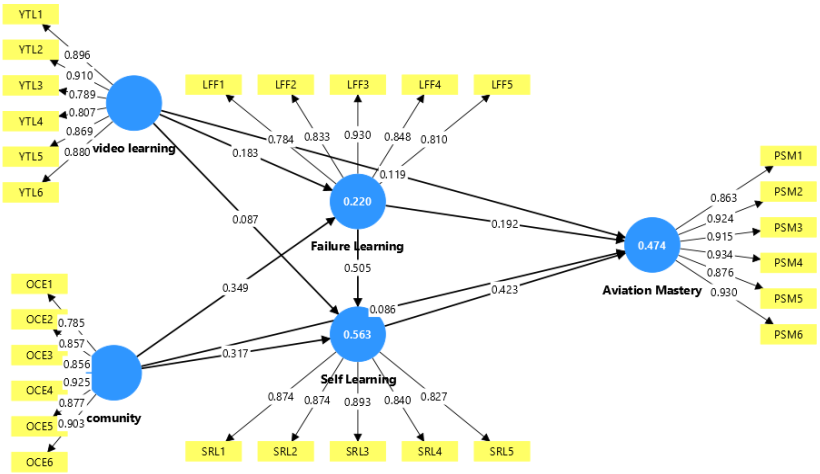


Figure 3. Measurement Model

The measurement model was evaluated to assess the validity and reliability of the research constructs. Convergent validity was examined by assessing the outer loadings and the Average Variance Extracted (AVE), using the recommended threshold values of outer loadings greater than 0.70 and AVE values exceeding 0.50.

Table 1. Outer loadings and cross-loadings

Item	DSM	LFF	OCE	SRL	YBL
DSM1	**0.863**	0.427	0.413	0.555	0.398
DSM2	**0.924**	0.516	0.416	0.601	0.332
DSM3	**0.915**	0.518	0.375	0.593	0.434
DSM4	**0.934**	0.545	0.475	0.601	0.426
DSM5	**0.876**	0.477	0.456	0.581	0.315
DSM6	**0.930**	0.551	0.462	0.626	0.339
LFF1	0.507	**0.784**	0.397	0.484	0.336
LFF2	0.464	**0.833**	0.391	0.494	0.294
LFF3	0.517	**0.930**	0.333	0.661	0.261
LFF4	0.545	**0.848**	0.324	0.610	0.331
LFF5	0.303	**0.810**	0.430	0.585	0.294
OCE1	0.456	0.361	**0.785**	0.437	0.376
OCE2	0.381	0.329	**0.857**	0.509	0.377
OCE3	0.481	0.331	**0.856**	0.571	0.371
OCE4	0.416	0.421	**0.925**	0.527	0.431
OCE5	0.362	0.426	**0.877**	0.522	0.553
OCE6	0.384	0.432	**0.903**	0.462	0.522
SRL1	0.637	0.605	0.480	**0.874**	0.389
SRL2	0.500	0.548	0.471	**0.874**	0.328
SRL3	0.597	0.572	0.547	**0.893**	0.354
SRL4	0.521	0.657	0.517	**0.840**	0.357
SRL5	0.553	0.523	0.495	**0.827**	0.413
YBL1	0.346	0.289	0.491	0.264	**0.896**
YBL2	0.381	0.329	0.463	0.342	**0.910**
YBL3	0.385	0.308	0.279	0.405	**0.789**

Item	DSM	LFF	OCE	SRL	YBL
YBL4	0.274	0.185	0.296	0.316	**0.807**
YBL5	0.382	0.343	0.529	0.377	**0.869**
YBL6	0.335	0.356	0.514	0.461	**0.880**

Bold values indicate each item's outer loading on its assigned construct. DSM = Digital Skill Mastery; LFF = Learning from Failure; OCE = Online Community Engagement; SRL = Self-Regulated Learning; YBL = YouTube-Based Learning.

Table 2. Heterotrait–monotrait ratio (HTMT)

Construct	DSM	LFF	OCE	SRL	YBL
DSM	—	0.598	0.504	0.697	0.433
LFF	0.598	—	0.487	0.743	0.386
OCE	0.504	0.487	—	0.629	0.536
SRL	0.697	0.743	0.629	—	0.456
YBL	0.433	0.386	0.536	0.456	—

Table 3. Fornell–Larcker criterion

Construct	DSM	LFF	OCE	SRL	YBL
DSM	**0.907**	0.559	0.477	0.654	0.412
LFF	0.559	**0.843**	0.442	0.676	0.359
OCE	0.477	0.442	**0.868**	0.583	0.505
SRL	0.654	0.676	0.583	**0.862**	0.428
YBL	0.412	0.359	0.505	0.428	**0.860**

Discriminant validity was assessed using cross-loadings, the heterotrait–monotrait ratio (HTMT), and the Fornell–Larcker criterion. All items exhibited their highest loadings on their respective constructs, with outer loadings ranging from 0.784 to 0.934. The HTMT values ranged from 0.386 to 0.743, remaining below the conservative threshold of 0.85. In addition, the square root of the average variance extracted (AVE) for each construct exceeded its correlations with the other constructs, satisfying the Fornell–Larcker criterion. As illustrated in Figure 1,2, and 3, taken together, these results provide convergent evidence supporting the discriminant validity of the measurement model.

As illustrated in Figure 3, all indicators exhibited outer loading values above 0.70, indicating that the measurement items satisfied the criterion for convergent validity. Furthermore, the results of the AVE analysis are presented in Table. 4

Table 4. Result of Reliability Analysis

	Cronbach's alpha	Composite reliability (rho_c)	Average variance extracted (AVE)
YouTube-Based Learning (YBL)	0.929	0.944	0.739
Online Community Engagement (OCE)	0.934	0.948	0.754
Learning from Failure (LFF)	0.897	0.924	0.709
Self-Regulated Learning (SRL)	0.913	0.935	0.743
Aviation Mastery (DSM)	0.957	0.965	0.823

All constructs demonstrated AVE values greater than 0.50, indicating that each construct achieved adequate convergent validity. Construct reliability was subsequently assessed using Cronbach's Alpha and Composite Reliability. The Cronbach's Alpha and Composite Reliability values for all constructs exceeded the recommended threshold of 0.70, indicating that all constructs demonstrated satisfactory internal consistency and were considered reliable.

The inner VIF results indicated that multicollinearity was not a concern in the structural model. For the Learning from Failure construct, the VIF values for Online Community Engagement and YouTube-Based Learning were both 1.342. For Self-Regulated Learning, the VIF values ranged from 1.282 to 1.499. For Aviation Mastery, the VIF values ranged from 1.402 to 2.288, with Self-Regulated Learning showing the highest VIF (2.288). Thus, all inner VIF values were below the conservative threshold of 3.00 and substantially below the commonly used threshold of 5.00, indicating that the predictor constructs did not exhibit problematic multicollinearity.

Table 5. Result of inner VIF values

Endogenous Construct	Predictor	VIF
Failure Learning	Online Community Engagement	1.342
Failure Learning	YouTube-Based Learning	1.342
Self-Regulated Learning	Online Community Engagement	1.499
Self-Regulated Learning	Failure Learning	1.282
Self-Regulated Learning	YouTube-Based Learning	1.385
Aviation Mastery	Online Community Engagement	1.727
Aviation Mastery	Failure Learning	1.866
Aviation Mastery	Self-Regulated Learning	2.288
Aviation Mastery	YouTube-Based Learning	1.402

A full-collinearity assessment was also conducted to examine potential common method bias because the study relied on self-reported measures collected from a single respondent source. The resulting full-collinearity VIF values ranged from 1.429 to 2.628 across the five constructs. The highest value was observed for Self-Regulated Learning (VIF = 2.628), which remained below the

3.30 threshold. Therefore, the full-collinearity assessment did not indicate substantial common method bias in the data.

Table 6. Result of full-collinearity VIF values

Construct	Full-Collinearity VIF
Aviation Mastery	1.901
Failure Learning	1.936
Self-Regulated Learning	2.628
Online Community Engagement	1.741
YouTube-Based Learning	1.429

Taken together, the inner VIF and full-collinearity results indicate that neither excessive predictor collinearity nor substantial common method variance appears to be a major threat to the interpretation of the structural model. Accordingly, the non-significant relationships observed for Online Community Engagement → Aviation Mastery, Failure Learning → Aviation Mastery, YouTube-Based Learning → Aviation Mastery, and YouTube-Based Learning → Self-Regulated Learning are not accompanied by evidence of problematic collinearity in the structural predictors.

Structural Model (Inner Model) Assessment

Table 7. Result of Inner Model Assessment

	R-square	R-square adjusted	Interpretation
Aviation Mastery	0.474	0.450	Moderate
Failure Learning	0.220	0.203	Weak
Self Learning	0.563	0.548	Moderate

The model explained 22.0% of the variance in Learning from Failure, 56.3% of the variance in Self-Regulated Learning, and 47.4% of the variance in Digital Skill Mastery. Based on commonly used PLS-SEM benchmarks, the explanatory power for Learning from Failure is relatively weak, while the explanatory power for Self-Regulated Learning and Digital Skill Mastery is moderate. Thus, the model provides meaningful explanatory power but does not demonstrate substantial explanatory power for the endogenous constructs.

Hypothesis Testing

Hypothesis testing was conducted using the bootstrapping procedure within the PLS-SEM framework to evaluate the significance of the proposed structural relationships.

Table 8. Result of Hypothesis Testing

Hypothesis	Process	β	p-value	Result
H1	Community → Aviation Mastery	0.086	0.309	Not Significant
H2	Community → Learning from Failure	0.349	0.001	Significant

Hypothesis	Process	β	p-value	Result
H3	Community → Self-Learning	0.317	0.026	Significant
H4	Learning from Failure → Aviation Mastery	0.192	0.062	Not Significant
H5	Learning from Failure → Self Learning	0.505	0.000	Significant
H6	Self Learning → Aviation Mastery	0.423	0.003	Significant
H7	Video Learning → Aviation Mastery	0.119	0.051	Not Significant
H8	Video Learning → Learning from Failure	0.183	0.025	Significant
H9	Video Learning → Self Learning	0.087	0.154	Not Significant

Table 8 presents the results of the structural model assessment. Hypothesis H1, which examined the relationship between Online Community Engagement and Aviation Mastery, was not supported ($\beta = 0.086$, $p = 0.309$). This finding indicates that participation in online professional communities does not directly enhance technicians' digital technical competencies. Merely belonging to a professional community is insufficient to improve technical mastery; rather, technicians need to actively engage in discussions, reflect on failure experiences, and apply shared solutions before competency improvements can be achieved. This finding is consistent with Wenger's Communities of Practice theory, which argues that learning emerges through active participation and shared practice rather than simple community membership (Wenger-Trayner, 2021).

Hypothesis H2, examining the effect of Online Community Engagement on Learning from Failure, was supported ($\beta = 0.349$, $p = 0.001$). The positive relationship suggests that technicians who participate more actively in professional communities are more likely to learn from failure experiences. Online communities provide opportunities to discuss technical failures, exchange troubleshooting strategies, and share practical solutions. This finding supports the concept of tacit knowledge sharing, whereby practical knowledge is transferred through social interaction and shared experience (Nonaka, 2009).

Hypothesis H3, which proposed a positive relationship between Online Community Engagement and Self-Regulated Learning, was also supported ($\beta = 0.317$, $p = 0.026$). This result indicates that participation in professional communities facilitates the development of self-regulated learning by providing access to new learning resources, constructive feedback, and learning motivation. The finding is consistent with Zimmerman's socially scaffolded self-regulated learning framework, which emphasizes the importance of social interaction in fostering autonomous learning capabilities (Zimmerman, 2008).

Hypothesis H4, investigating the relationship between Learning from Failure and Aviation Mastery: this p-value (0.062) is marginal/borderline, not clearly non-significant. This is explicitly approaching significance and a possible Type II error given n=100

Hypothesis H5 demonstrated the strongest relationship in the proposed model. Learning from Failure had a significant positive effect on Self-Regulated Learning ($\beta = 0.505$, $p < 0.001$). This finding suggests that failure experiences encourage technicians to seek additional information, evaluate previous strategies, and experiment with alternative solutions, thereby strengthening their capacity

for self-regulated learning. The result strongly supports Experiential Learning Theory and Error Management Theory, which emphasize learning through reflection on experience and errors (Kolb, 2014). This reflective process on errors fosters what is known as 'negative knowledge'—knowing what not to do—which is crucial for professional development (Gartmeier et al., 2021) .

Hypothesis H6, examining the influence of Self-Regulated Learning on Aviation Mastery, was supported (β = 0.423, p = 0.003). This finding indicates that self-regulated learning is a key predictor of digital technical competence. Technicians who actively set learning goals, monitor their progress, and evaluate their learning outcomes are more successful in mastering digital engineering skills. The result provides strong empirical support for Zimmerman's Self-Regulated Learning Theory.

Hypothesis H7, which examines the direct effect of YouTube-Based Learning on Aviation Mastery, has a threshold value (β = 0.119, p = 0.051). This finding suggests that watching instructional videos might not directly boost technical competency levels. While YouTube is effective for providing procedural knowledge and visual demonstrations, it doesn't necessarily develop the troubleshooting skills needed to solve real-world problems on the job.

Hypothesis H8, examining the relationship between YouTube-Based Learning and Learning from Failure, was supported (β = 0.183, p = 0.025). The result indicates that instructional videos assist technicians in recognizing procedural errors by allowing them to compare recommended practices with actual workplace situations. Consequently, YouTube-based learning facilitates error recognition and supports reflection on alternative troubleshooting strategies, although its effect size is relatively modest.

Finally, Hypothesis H9, which proposed a positive relationship between YouTube-Based Learning and Self-Regulated Learning, was not supported (β = 0.087, p = 0.154). This finding suggests that simply watching instructional videos does not automatically foster self-regulated learning. Instead, self-regulated learning appears to develop primarily through practical experience, reflective processes, and social interaction rather than through passive consumption of video-based instructional content.

Mediation Testing

Table 9. Result of Mediation Testing

	Original sample (O)	T statistics (|O/STDEV|)	P values	
comunity -> Self Learning -> Aviation Mastery	0.134	1.117	0.132	Not Proven
comunity -> Failure Learning -> Aviation Mastery	0.067	1.359	0.087	Not Proven
video learning -> Self Learning -> Aviation Mastery	0.037	0.970	0.166	Not Proven
comunity -> Failure Learning -> Self Learning -> Aviation Mastery	0.075	1.554	0.060	Not Proven
video learning -> Failure Learning -> Aviation Mastery	0.035	0.932	0.176	Not Proven
comunity -> Failure Learning -> Self Learning	0.176	2.205	0.014	Proven

	Original sample (O)	T statistics (|O/STDEV|)	P values	
video learning -> Failure Learning -> Self Learning -> Aviation Mastery	0.039	1.620	0.053	Not Proven
video learning -> Failure Learning -> Self Learning	0.092	1.525	0.064	Not Proven
Failure Learning -> Self Learning -> Aviation Mastery	0.214	2.757	0.003	Proven

The mediation analysis revealed that not all indirect pathways produced significant mediation effects when the mediating variables were examined simultaneously. The first significant indirect effect was observed in the pathway from Online Community Engagement to Self-Regulated Learning through Learning from Failure (β = 0.176, p = 0.014). This finding indicates that participation in online professional communities enhances self-regulated learning by facilitating learning from failure. Active engagement in professional communities provides technicians with opportunities to discuss troubleshooting cases, exchange failure experiences, and reflect on practical challenges, which subsequently encourages them to regulate and direct their own learning processes.

A second significant mediation effect was identified in the pathway from Learning from Failure to Aviation Mastery through Self-Regulated Learning (β = 0.214, p = 0.003). This result demonstrates that learning from failure does not directly improve technical competence but contributes to competency development by strengthening self-regulated learning. In other words, experiencing failure alone is insufficient to improve professional expertise; rather, failure becomes beneficial when it stimulates technicians to engage in self-directed learning, evaluate their existing knowledge, and acquire new competencies. However, it's important to note that only 2 out of 9 mediating effects were supported, so this finding needs further investigation. This finding is consistent with Self-Regulated Learning Theory, Experiential Learning Theory, and Error Management Theory (Zimmerman, 2008; Kolb, 2014).

In contrast, the indirect effect of Online Community Engagement on Aviation Mastery through Self-Regulated Learning was not statistically significant (β = 0.134, p = 0.132). Although Online Community Engagement significantly influenced Self-Regulated Learning, and Self-Regulated Learning significantly influenced Aviation Mastery, the indirect relationship between community participation and technical competence through self-regulated learning alone was insufficient to reach statistical significance. This suggests that the primary contribution of online communities lies in facilitating learning from failure before influencing self-regulated learning and ultimately technical competence.

Similarly, the sequential mediation pathway from Online Community Engagement to Aviation Mastery through Learning from Failure and Self-Regulated Learning was not statistically significant (β = 0.075, p = 0.060), although the result approached the conventional significance threshold. This marginally significant effect suggests that the proposed sequential mediation mechanism may exist but could not be conclusively demonstrated with the current sample size. A larger sample may provide greater statistical power to detect this indirect relationship.

None of the mediation pathways involving YouTube-Based Learning were statistically significant. Specifically, the indirect effects through Self-Regulated Learning (p = 0.166), through Learning from Failure (p = 0.176), through Learning from Failure and Self-Regulated Learning (p = 0.053), and through Learning from Failure to Self-Regulated Learning (p = 0.064) all failed to reach statistical significance. These findings suggest that although YouTube-based learning serves as an effective source of procedural and technical information, it is not sufficiently influential to foster self-regulated learning or enhance Aviation Mastery through indirect learning mechanisms. Compared with professional community participation, YouTube appears to function primarily as an informational resource rather than as a catalyst for reflective learning, experiential knowledge construction, and competency development.

4. DISCUSSION

The findings indicate that Online Community Engagement exerts the strongest positive influence on Learning from Failure. This result suggests that online professional communities provide an important environment in which technicians can share failure experiences, discuss troubleshooting strategies, and collaboratively develop solutions to complex technical problems. The finding supports Wenger's Communities of Practice theory, which posits that learning emerges through active participation in communities that share common practices and professional experiences.

The study also reveals that the contribution of YouTube-Based Learning to Aviation Mastery is relatively weaker than that of online community engagement. This finding suggests that instructional videos are effective for developing foundational procedural knowledge but are less capable of addressing the diversity of operational errors and complex real-world situations encountered in professional practice. Consequently, acquiring advanced digital technical skills requires more than passive consumption of instructional videos; it also depends on social interaction, collaborative problem-solving, and practical experience.

The non-significant structural relationships should therefore not be attributed to problematic multicollinearity. The inner VIF values were consistently below 3.00, while the full-collinearity VIF values were also below 3.30. These results suggest that excessive overlap among the predictor constructs or substantial common method variance is unlikely to explain the non-significant paths. Instead, the findings suggest that the effects of online community engagement and video-based learning on aviation mastery may depend on intervening learning processes rather than operating as direct associations. In particular, the significant relationship between Self-Regulated Learning and Aviation Mastery indicates that the regulation of learning may represent a more proximal mechanism for explaining technical skill development than exposure to learning resources alone.

Furthermore, Learning from Failure was found to have a significant positive effect on Self-Regulated Learning. This result indicates that failure experiences encourage learners to reflect on their performance, evaluate their learning strategies, and seek alternative solutions. Such reflective processes strengthen learners' ability to regulate and direct their own learning, consistent with Zimmerman's Self-Regulated Learning Theory.

The findings further demonstrate that Self-Regulated Learning is the strongest predictor of Aviation Mastery. This suggests that successful acquisition of digital technical competencies largely depends on individuals' ability to manage their own learning processes, including selecting

appropriate learning resources, implementing effective learning strategies, monitoring their progress, and evaluating learning outcomes.

Overall, the results indicate that digital technical skill mastery in the contemporary digital era is shaped not only by access to instructional video resources but also by learning from failure and active participation in online professional communities. These findings reinforce the perspective that digital technical learning is fundamentally a social and reflective process involving the integration of explicit knowledge acquired from formal learning resources and tacit knowledge developed through practical experience and collaborative interaction.

A key contribution of this study is the identification of Self-Regulated Learning as a proximal predictor of Aviation Mastery and the significant indirect pathway from Learning from Failure through Self-Regulated Learning to Aviation Mastery. The findings further show that Online Community Engagement is significantly associated with Learning from Failure and Self-Regulated Learning, whereas the indirect effects of YouTube-Based Learning on Aviation Mastery were not statistically significant. Thus, the findings suggest that access to digital learning resources alone may be insufficient to explain technical skill mastery; rather, reflective and self-regulated learning processes appear to play a more proximal role.

5. CONCLUSION

Contrary to the common assumption that digital technical competence can be developed primarily through YouTube tutorials, this study demonstrates that aviation technicians achieve Aviation Mastery mainly through a socially mediated learning process. Online professional communities facilitate learning from failure, providing evidence consistent with the proposed self-regulated learning mechanism and ultimately enhancing digital technical competence. These findings suggest that the value of digital learning lies not merely in the consumption of digital content but in the reflective and collaborative processes through which professional experiences are transformed into technical competence.

The findings further indicate that online communities do not directly generate technical mastery. Rather, they create opportunities for technicians to encounter, discuss, analyze, and reflect upon operational failures. These shared experiences promote self-regulated learning, which subsequently contributes to the development of Aviation Mastery in aviation technical practice.

From a theoretical perspective, this study integrates the Communities of Practice, experiential learning, error-based learning, and Self-Regulated Learning perspectives to examine how community-based learning from failure is associated with self-regulated learning and technical skill mastery.

From a practical perspective, the findings provide important implications for aviation service organizations to strengthen the technical competencies of aviation personnel; organizations should establish internal professional communities that facilitate discussions, troubleshooting, and collaborative problem-solving among technicians. In addition, organizations should develop a structured failure-case knowledge repository to capture and preserve tacit knowledge derived from operational experiences, enabling technicians to access, share, and continuously learn from previous technical failures.

6. REFERENCES

Abedini, A., Abedin, B., & Zowghi, D. (2024). A framework of environmental, personal, and behavioral factors of adult learning in online communities of practice. *Information Systems Frontiers*, *26*(3), 1201–1218. https://doi.org/10.1007/s10796-023-10417-2

Broadbent, J., Panadero, E., Lodge, J. M., & de Barba, P. (2021). Technologies to support self-regulated learning in online and blended learning environments. *Computers & Education*, *175*, 104321. https://doi.org/10.1016/j.compedu.2021.104321

Buunk, I., & Smith, C. F. (2018). Tacit knowledge sharing in online environments: Locating "Ba" within a platform for public sector professionals. *Journal of Librarianship and Information Science*, *51*(4), 1144–1155. https://doi.org/10.1177/0961000618769982

Creswell, J. W. (2023). *Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). Sage Publications.

Feldman-Maggor, Y. (2024). Navigating the online learning journey by self-regulation: Teachers as learners. *Computers & Education*, *219*, 105074. https://doi.org/10.1016/j.compedu.2024.105074

Gartmeier, M., Bauer, J., Gruber, H., & Heid, H. (2021). Negative knowledge: The role of learning from errors in professional development. *Educational Research Review*, *34*, 100411. https://doi.org/10.1016/j.edurev.2021.100411

Greeves, S. (2024). YouTube in higher education: Comparing student and instructor perceptions and practices. *Frontiers in Education*, *8*, 1330405. https://doi.org/10.3389/feduc.2023.1330405

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). *A primer on partial least squares structural equation modeling* (PLS-SEM) (3rd ed.). Sage Publishing.

Keith, N., & Frese, M. (2023). Error management training for safety-critical occupations: Enhancing adaptive transfer through failure reflection. *Safety Science*, *162*, 106103. https://doi.org/10.1016/j.ssci.2023.106103

Kohler, S., & Dietrich, T. C. (2021). Potentials and limitations of educational videos on YouTube for science communication. *Frontiers in Communication*, *6*, 581302. https://doi.org/10.3389/fcomm.2021.581302

Kolb, A. Y. (2014). On becoming an experiential educator: The educator role profile. *Simulation & Gaming*, *45*(2), 204–234. https://doi.org/10.1177/1046878114534383

Kyndt, E., & Baert, H. (2022). Informal learning in the workplace: A review of systemic and individual factors. *Human Resource Development Review*, *21*(2), 154–187. https://doi.org/10.1177/15344843221081023

Margaryan, A. (2024). The duality of global online labour platforms as restrictive-expansive sites of workplace learning and skill development. *International Journal of Training and Development*, *28*(3), 315–334. https://doi.org/10.1111/ijtd.12326

Mayer, R. E. (2021). Evidence-based principles for how to design effective instructional videos. *Journal of Applied Research in Memory and Cognition*, *10*(2), 229–240. https://doi.org/10.1016/j.jarmac.2021.03.007

Noetel, M., Griffith, S., Delaney, O., Sanders, T., Parker, P., del Pozo Cruz, B., & Lonsdale, C. (2021). Video improves learning in higher education: A systematic review and meta-analysis. *Review of Educational Research*, *91*(2), 204–236. https://doi.org/10.3102/0034654321990713

Nonaka, I. (2009). Tacit knowledge and knowledge conversion: Controversy and advancement in organizational knowledge creation theory. *Organization Science*, *20*(3), 635–652. https://doi.org/10.1287/orsc.1080.0412

Ribeiro, R. (2021). Sharing tacit knowledge through digital communities of practice: A critical review of enablers and barriers. *Journal of Knowledge Management*, *25*(6), 1432–1451. https://doi.org/10.1108/JKM-08-2020-0612

Sarstedt, M., Ringle, C. M., & Hair, J. F. (2021). Partial least squares structural equation modeling in business and social sciences: Updated guidelines and applications. *Journal of Business Research*, *135*, 345–358. https://doi.org/10.1016/j.jbusres.2021.06.035

Tummons, J., & Tummons, J. (2025). Learning, instruction and assessment in the workplace: Applying and augmenting Communities of Practice theory. *Studies in Continuing Education*, *47*(3), 403–417. https://doi.org/10.1080/0158037X.2024.2372490

Veith, J. M., Winkler, B., Zenger, T., & Kulgemeyer, C. (2024). Exploring the relationship between surface features and explaining quality of YouTube explanatory videos. *Journal of Computer Assisted Learning*, *40*(1), 25–48. https://doi.org/10.1111/jcal.12854

Wenger-Trayner, E. (2021). Communities of practice: They live by the value they produce! In *Communities of innovation: How organizations harness collective creativity and build resilience* (pp. 359–369).

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal*, *45*(1), 166–183. https://doi.org/10.3102/0002831207312909.