A Method To Assess Barriers To Implementing Training Technologies

Blake CW Martin, Jerzy Jarmasz
Defence Research and Development Canada
Toronto, ON
Blake.Martin@forces.gc.ca,
Jerzy.Jarmasz@forces.gc.ca

ABSTRACT

Instructional technology is widely used across adult training and education organizations, including the Canadian Armed Forces (CAF), but its adoption faces multifaceted challenges beyond mere functionality. While technology adoption and system usability models highlight interactions between users and technology, they do not focus on institutional factors that can impede adoption of a technology. Pat Reid's 2014 framework identifies five key barriers within an organization's training ecosystem: Technology, Process, Administration, Environment, and Faculty. Adapting these to the military context, we developed a methodology to gather individual and institutional perspectives on barriers to implementing a technology. We created a questionnaire featuring both open-ended questions and Likert-style risk assessments to solicit detailed individual responses, and a supplementary two-day workshop to contextualize and focus the application of the questionnaire with respect to specific systems and use cases. The methodology revealed shared barriers and helped to identify solution paths across diverse contexts. Analysis highlighted principal themes that crossed barrier categories, including as Time Scarcity, System Reliability, and Personnel, and provided insights for design considerations to address these institutional impediments. Notably, workshops held during the COVID-19 pandemic underscored the methodology's adaptability to online environments. Through NVivo analysis, nearly 2000 responses were coded and gathered into themes, informing design considerations for a crew training simulator, and a weapons effects system. The method was used to refine requests for proposals for these acquisitions, requiring bidders to address identified institutional issues such as continuity of knowledge due to succession, or access to technology and resources in remote and austere locations. This paper outlines the methodology's development, structure, and outcomes, emphasizing its utility in addressing technology adoption challenges within military training and education. Limitations, such as the complexity and duration of the Barriers data collection, and avenues for future refinement are also discussed.

ABOUT THE AUTHORS

Blake Martin holds a PhD in Kinesiology and a Graduate Diploma in Neuroscience from York University, a B.F.A. and M.A. in dance, and a Bachelor of Education. His doctoral research was in neural mechanisms of attention when trying to perform more than one movement at a time. His current research and work centers around thinking and learning in Canadian soldiers, instructional method selection, and systemic barriers to the use of instructional technology. If it thinks and moves, he likes it.

Jerzy Jarmasz Dr. Jerzy Jarmasz is a Defence Scientist at Defence Research and Development Canada (DRDC). With backgrounds in both electrical engineering and cognitive science, he brings a multidisciplinary approach to all of his projects. His areas of expertise include simulation-based training, training for cognitive skills (e.g., situation awareness, decision-making) and team effectiveness training at the tactical, operational and strategic levels.

A method to assess barriers to implementing training technologies: A study of two cases in the Canadian Armed Forces

Blake CW Martin, Jerzy Jarmasz
Defence Research and Development Canada
Toronto, ON
Blake.Martin@forces.gc.ca,
Jerzy.Jarmasz@forces.gc.ca

BACKGROUND

Professional training and development organizations including militaries such as the Canadian Armed Forces use instructional technologies to improve the efficacy and efficiency of training. Various models have been developed to examine and describe the acceptance and useability of such technologies. Among these are the Theory of Reasoned Action (TRA) the Technology Acceptance Model (TAM), and the Unified Technology Adoption and User Theory (UTAUT) (Alshammari & Rosli, 2018; Taherdoost, 2018). These models focus on user perception of utility and facility of use, and importantly, have some predictive power with respect to individual use and uptake of a technology. Despite considerable effort to ensure effectiveness, reliability and user buy-in, even the most promising technology may fail to deliver its intended results.

The use of a given technology for learning presents two very particular problems. The first is that the technology cannot simply be 'good' or useful in general, it must promote learning. A well-designed, well-received technology does not guarantee the intended educational outcomes: the distracting presence of smartphones in classrooms is an excellent case in point. The second problem is that educational organizations express a sort of ecosystem of inter-related parts including the infrastructures and technology of the organization, the processes used to deliver training, the administration, the training stakeholders – in particular faculty and instructional designers, and finally the cultural or ideological environment of the organization. Shortcomings in any of these areas or in the ways they interact with one another might seriously or even catastrophically impact the success of a given technology within that organization. One can hope such shortcomings won't happen, but experience shows otherwise; proactively anticipating ways in which the ecosystem may create barriers to the use of perfectly good technologies may avoid costly post-hoc mitigations or outright failure. Pat Reid (2014) reviewed literature on failures to implement instructional technology in adult learning and categorized them into five overarching groups: 1) The *technology itself* with respect to the instructional personnel, 2) the institutional *process* of introducing and preparing for use of the technology, 3) the *administration* of the new instructional technology within the organization, 4) the *environment* and culture of the organization with respect to the use of the technology for learning, and 5) the *training stakeholders* who themselves must learn and apply the technology[1]. Each category is subsequently divided into further subcategories which capture particular aspects of the instructional ecosystem and can act as a filter or lens to examine an institution's capacity to embrace new instructional technologies.

Using a modification of Reid's categories, we developed a method to systematically examine the implementation of an instructional technology within an organizational context. In addition to changing the name of the *Faculty* barrier to *Training Stakeholders*, we added a *Collective Training* subcategory to the *Process* category, recognizing that in armed forces contexts, the competing training objectives, personnel and asset availability and scheduling and coordination may introduce additional layers of complexity beyond individual training. Early versions of the method using just the categories as collection bins, and subsequently a questionnaire, were piloted on efforts with both a NATO activity and The Technical Cooperation Program (TTCP), where we saw excellent alignment between Reid's categories and observed barriers to the implementation of distributed interactive simulation, and two prototype

[1] Reid originally used the term 'Faculty', however, in many military contexts, the instructor does not make the final decision about what technology gets used, rather leaders of training establishments, instructional designers and developers and other stakeholders make such decisions.

software tools, respectively. We then more fully developed the questionnaire, and created a focus group structure to contextualize and support the survey data collection, a matter of particular importance when an instructional technology is proposed or speculative (i.e., the technology has not yet been developed).

The present work considers two different data collections in support of major capital acquisitions by the Canadian Armed Forces (CAF). The first was for SOLUTION 1, a purpose-built, network-connected simulation training system. Its intent is to offer both individual and collective training for a number of Canadian Army combat vehicles. The second collection supported SOLUTION 2, a prospective improvement for systems for supporting live, force-on-force training for land operations which aims to integrate recent advances in technology and process.

METHODS

Methods, materials, and analysis techniques differed slightly between the two data collections. First, the COVID 19 global pandemic forced a switch from in-person to virtual data collections after our very first focus group for SOLUTION 1. Between the SOLUTION 1 and SOLUTION 2 data collections, the main Barriers questionnaire was revised based on lessons learned during data collection and independent critiques. These changes included elimination of double-barreled questions, clarifications of wording, and the implementation of survey logic to improve statistical validity of Likert responses. An internal review of the focus group procedures and secondary questionnaires was also undertaken by the authors. Both review processes resulted in changes to the data collection that prevent direct comparison of numerical values between the two datasets, and further changes in the application and use of the NVivo software that prevents comparison of numerical aspects of the numbers and percentages of coded themes. However, the categorization of the barriers and the grounded approach to theme development remains the same. The main Barriers survey, the role definition survey, and other electronic and physical means were used to gather participant input.

Participants

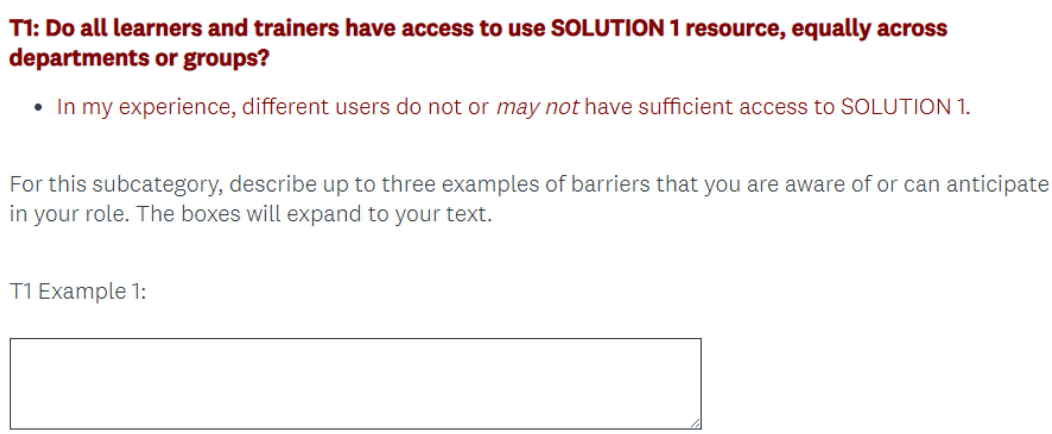
For both collections, participants were from Canadian Army Divisions. For SOLUTION 1 there were a total fifty-six participants: 16 from 2nd Canadian Division (2DIV) all Francophone; 14 from 3rd Canadian Division (3DIV); 10 from 4th Canadian Division (4DIV); and 17 from 5th Canadian Division (5DIV). These focus groups included primary training audience (armoured, artillery, support, engineering), instructors, training development officers, technical personnel and those involved in oversight of training, ranking from Private to Captain. For SOLUTION 2, there were forty-nine participants: 11 from 2DIV, all Francophone; 23 from 3DIV; and 15 from 4DIV. This sample included primary and secondary training audience learners (command, armoured, artillery, infantry, signals, etc.), Observer Controller Trainers (OCT), Observer Analysts (OA), Combat Support Services (CSS) personnel, technical personnel, training leaders, exercise planners, site service management personnel and others, and ranged in rank from Private to Lieutenant Colonel. The focus groups for 2DIV were conducted entirely in French. The convenience samples relied on personnel availability at the participating bases and not all desired demographic parameters could be met (e.g., only two women volunteered for SOLUTION 1 and one for SOLUTION 2), and administrative and process personnel were poorly represented for both collections. All participants provided informed consent, and the data collections were reviewed and approved by DRDC’s Human Ethics Research Committee (Protocols 2020-005, 2020-005 – Amendments 1 and 2).

Focus Group Structure

Data collection took place over two days, from 0800 to 1600 hours local time for each focus group. In the days prior to all virtual focus groups, participants were given an opportunity to check connectivity and to become oriented to the Teams environment. After providing informed consent, participants were oriented to collection procedures. After this, research assistants pseudo-randomly sorted participants into different breakout group configurations to be used throughout the collection, promoting the likelihood that all participants would eventually interact with most other participants. A high-level brief was provided for the solution in question to frame the conversation and manage blue-sky thinking. Participants then filled in a survey providing information on their role with respect to the solution, and demographics. For the remainder of the first day, participants were led through an engineering design activity: first, they listed and defined possible use cases for the technology; then subsequently identified key features or functionalities to support each use case; and finally traced the key features back to all uses cases. On the second day, participants filled in the Barriers survey, then were presented with the summaries of the Likert results. This allowed them to triage the most salient categories for that focus group. Based on these collective evaluations, they selected three top categories and then used a discussion technique to generate possible solutions to a given Barrier problem.

Barriers Survey

The Barriers questionnaire has an introductory page describing the survey and instructions for its use, followed by a page explaining all barriers subcategories in brief. On this page, the participant is presented with a question followed by a 'yes' and 'no statements, for example: "T1: Do all learners and trainers have access to use the technology resource, equally across departments or groups?" followed by "In my experience, different users do not or may not have sufficient access to the technology ['yes' answer]." and "I am not aware of this barrier at all ['no' answer]." If they identify awareness of the barriers, they are given an opportunity to provide up to three examples of instances of a barrier being present for that category (Figure 1). Then, the participant is asked to rate, on a 5-point Likert scale, the likelihood of the barrier being present (Presence) followed by a similar 5-point rating of the impact of that barrier on the use of the instructional solution (Impact) (Figure 2).



T1: Do all learners and trainers have access to use SOLUTION 1 resource, equally across departments or groups?

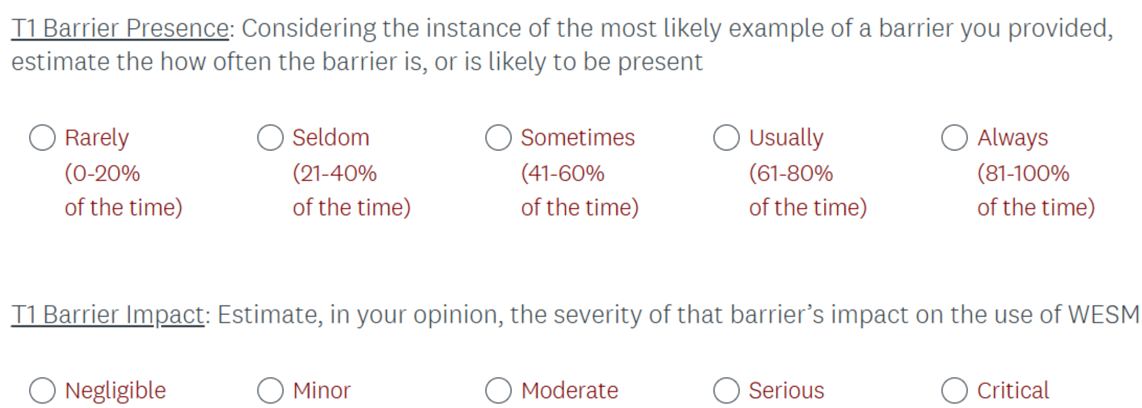
- In my experience, different users do not or *may not* have sufficient access to SOLUTION 1.

For this subcategory, describe up to three examples of barriers that you are aware of or can anticipate in your role. The boxes will expand to your text.

T1 Example 1:

Figure 1. Screenshot Of Barriers Questionnaire "Example Prompt" From Surveymonkey

The participant sees the above screen after identifying that there is a Barrier in the identified subcategory. Participants are given up to 3 example boxes.



T1 Barrier Presence: Considering the instance of the most likely example of a barrier you provided, estimate the how often the barrier is, or is likely to be present

Rarely (0-20% of the time) | Seldom (21-40% of the time) | Sometimes (41-60% of the time) | Usually (61-80% of the time) | Always (81-100% of the time)

T1 Barrier Impact: Estimate, in your opinion, the severity of that barrier's impact on the use of WESM.

Negligible | Minor | Moderate | Serious | Critical

Figure 2. Screenshot Of Barriers Questionnaire "Likert Scale" From Surveymonkey

The participant sees this screen after identifying that there is a Barrier in the identified subcategory. Participants are given up to 3 example boxes.

DATA ANALYSIS

In the SOLUTION 1 data collection, participants were provided with five-point Presence and Impact scales, with 'No observation' appended to the end of the scale (six choices). By contrast, in the SOLUTION 2 collection, participants were first presented with a 'No barrier observed/Barrier observed' forced-choice question. If they answered "Barrier Observed," survey logic presented them with two five-point scales (five choices). For this reason, while the differences can be examined across divisions for each technology, they cannot be examined between the two technologies, because the initial number of choices skews the distribution of responses. To approximate comparison for the presence and impact scales in the present work, however, we construed the categories as interval data (Norman, 2010), and present the means for each Barrier category and location.

All French language responses were translated into English for analysis. Each open answer survey response, and each other participant-written text response was labeled as a 'reference'. During the SOLUTION 2 data collection, transcripts of spoken conversations were broken into references, with each change of speaker being considered a new reference. All administrative comments and comments by experimenters or observers were excluded. References were collected and coded into the twenty-five barriers subcategories using NVivo qualitative data software. NVivo allows users to fluidly apply multiple coding categories to qualitative data without disturbing the source material, and permits the assignment of positive or negative sentiment to references, and gives advanced tools for examining relationships among coded references. Some references fit into more than one coding category. For example, a participant may have provided the example "We can never access the simulator because no admin staff are available" for the category *Technology 1, Access: In my experience, different users do not or may not have sufficient access to the technology*. However, this example also describes an issue with *Process 4*, *In my experience, support staff are not available or may not be available to provide the resources needed to facilitate use of the technology*. Some examples or references more accurately described a technology or feature and were removed from the barriers analysis and added to analysis of key features and functionalities.

Subsequently, all references were examined using a Grounded Theory approach (Singh & Estefan, 2018). Grounded Theory does not pre-suppose the existence of an explanatory model. Rather, themes are developed inductively, with like references from barriers categories being examined and re-examined until novel categories emerge. See Table 1, which demonstrates how references might be coded into themes following barriers categorization.

Table 1. Using Grounded Theory To Code Reference From Barriers Categories Into Themes.

Coding	Reference example
Barrier Category	
T1 Access	"Our unit always gets bumped by other units."
	"The kit is located too far away from us to ever use."
P4 Support Staff	"We can never get the Edmonton support staff out here."
	"Support staff are only for Reg Forces. Reservists are out of luck."
Theme Category	
Priorities	"Our unit always gets bumped by other units."
	"Support staff are only for Reg Forces. Reservists are out of luck."
Location/Centralization	"The kit is located too far away from us to ever use."
	"We can never get the Edmonton support staff out here."

RESULTS

We calculated values for the Likert scales, using numbers 1-5 as replacements for the text anchors. Results are presented below for the 'Presence' of the Barrier for each category, for each division that participated in the data collection for both SOLUTION 1 and SOLUTION 2. A score of 5 indicates that all participants in that division felt the barrier was always present (Figure 3). Similarly, for the ‘Impact’ scale, a score of 5 indicates that all participants in that division felt the barrier imposed a critical impact on the delivery of training using the technology (Figure 4). As described above, while the values cannot be compared between the two data collections due to methodological differences between them, the figure provides a rough guide to the how the presence and impact were perceived by the participants in each Division.

DIV	T1 Access	T2 Reliability	T3 Complexity	P1 Project Management	P2 Support to Adopt	P3 Technical Assistance	P4 Support Staff	P5 Learner Needs	P6 PD	P7 Collective Training	A1 Trainers Control Tech	A2 Institutional Support	A3 Estimation of Effort	A4 Recognition	A5 Time to Adopt	E1 Shifting Role	E2 Teacher Autonomy	E3 Tension with Culture	E4 Legal Concerns	E5 Technology Proven	TS1 Trainer Facility	TS2 Comfort with Change	TS3 Trainer Confidence	TS4 Percept of Tech	TS5 Willingness for PD
SOLUTION 1 BARRIER PRESENCE																									
1	3.5	3.6	3.1	3.4	3.2	3.1	2.5	2.7	3.1	3.6	3.2	2.7	3.5	3.3	3.7	3.9	2.8	3.2	3.8	2.5	2.9	2.7	2.9	3.0	2.8
2	3.4	3.3	3.2	3.6	3.3	3.2	3.0	3.5	3.0	3.3	3.2	3.0	2.8	2.0	3.4	3.0	3.7	3.0	3.0	3.5	3.6	4.3	2.7	3.4	2.7
3	4.0	3.9	3.4	3.8	4.0	3.8	3.4	3.7	3.4	4.2	3.3	3.3	4.3	3.7	4.6	4.3	3.3	3.7	3.5	4.8	3.9	3.1	4.1	3.9	4.4
4	3.7	3.4	3.1	3.3	3.2	3.3	2.7	2.4	3.7	2.8	2.5	3.0	2.8	3.1	3.0	3.3	3.6	3.0	3.0	3.2	2.9	3.1	3.3	2.6	2.6
Avg.	**3.6**	**3.6**	**3.2**	**3.5**	**3.4**	**3.3**	**2.9**	**3.1**	**3.3**	**3.5**	**3.0**	**3.0**	**3.4**	**3.0**	**3.7**	**3.6**	**3.4**	**3.2**	**3.3**	**3.5**	**3.3**	**3.3**	**3.3**	**3.2**	**3.1**
SOLUTION 2 BARRIER PRESENCE																									
2	3.6	3.3	3.4	3.0	3.7	3.2	2.0	3.3	4.2	4.4	4.0	3.0	3.0	3.5	4.0	3.5	0.0	0.0	0.0	4.0	3.5	2.5	3.0	4.0	3.0
3	3.4	3.5	3.1	3.3	3.4	2.8	3.1	3.0	3.7	3.9	3.6	4.6	3.4	4.0	3.6	4.0	4.0	3.3	3.3	3.1	3.3	2.9	3.4	4.0	3.4
4	4.1	3.0	2.6	3.6	4.2	3.3	4.3	3.3	3.8	4.5	4.6	4.5	3.8	4.5	3.8	3.4	0.0	2.3	3.0	3.0	4.3	3.3	3.7	3.2	2.0
Avg.	**3.7**	**3.3**	**3.0**	**3.3**	**3.8**	**3.1**	**3.1**	**3.2**	**3.9**	**4.3**	**4.1**	**4.0**	**3.4**	**4.0**	**3.8**	**3.6**	**1.3**	**1.9**	**2.1**	**3.4**	**3.7**	**2.9**	**3.4**	**3.7**	**2.8**

Figure 3: Barrier Present By Division For Each Instructional Solution
A score of 5 means all participants assessed the barrier to be always present. PD = Professional Development. Direct comparison between solutions is not possible because of differences in the structure of the questions.

DIV	T1 Access	T2 Reliability	T3 Complexity	P1 Project Management	P2 Support to Adopt	P3 Technical Assistance	P4 Support Staff	P5 Learner Needs	P6 PD	P7 Collective Training	A1 Trainers Control Tech	A2 Institutional Support	A3 Estimation of Effort	A4 Recognition	A5 Time to Adopt	E1 Shifting Role	E2 Teacher Autonomy	E3 Tension with Culture	E4 Legal Concerns	E5 Technology Proven	TS1 Trainer Facility	TS2 Comfort with Change	TS3 Trainer Confidence	TS4 Percept of Tech	TS5 Willingness for PD
SOLUTION 1 BARRIER IMPACT																									
1	3.5	3.5	2.7	3.7	3.3	1.7	2.6	2.5	3.0	2.7	2.5	2.7	3.5	3.3	3.7	3.9	2.8	3.2	3.8	2.5	2.9	2.7	2.9	3.0	2.8
2	3.5	3.4	2.7	2.8	3.0	3.8	3.1	3.0	2.3	2.6	3.3	3.0	2.8	2.0	3.4	3.0	3.7	3.0	3.0	3.5	3.6	4.3	2.7	3.4	2.7
3	4.3	4.0	3.5	3.3	4.0	4.0	3.9	3.1	3.8	3.6	4.1	3.3	4.3	3.7	4.6	4.3	3.3	3.7	3.5	4.8	3.9	3.1	4.1	3.9	4.4
4	3.1	2.8	3.3	2.0	2.8	3.8	2.0	3.6	3.1	2.6	2.6	3.0	2.8	3.1	3.0	3.3	3.6	3.0	3.0	3.2	2.9	3.1	3.3	2.6	2.6
Avg.	3.6	3.4	3.0	2.9	3.3	3.3	2.9	3.1	3.1	2.9	3.1	3.0	3.4	3.0	3.7	3.6	3.4	3.2	3.3	3.5	3.3	3.3	3.3	3.2	3.1
SOLUTION 2 BARRIER IMPACT																									
2	3.6	3.6	3.9	3.5	3.7	3.4	3.0	3.7	4.0	4.2	3.0	3.0	3.0	3.0	3.1	3.5	0.0	0.0	0.0	3.0	3.0	2.5	3.0	3.3	3.0
3	3.3	3.7	3.1	3.3	3.1	2.9	2.8	2.7	3.4	2.9	2.6	3.7	3.1	2.0	3.2	3.4	4.0	2.3	3.3	3.4	3.2	2.0	2.9	3.4	2.8
4	3.8	3.0	2.8	3.4	4.2	3.0	4.3	3.5	3.5	4.5	3.2	4.0	4.2	3.0	3.3	3.6	0.0	2.7	3.3	4.0	3.7	2.5	3.0	3.7	4.0
Avg.	3.6	3.4	3.2	3.4	3.6	3.1	3.4	3.3	3.6	3.9	2.9	3.6	3.4	2.7	3.2	3.5	1.3	1.7	2.2	3.5	3.3	2.3	3.0	3.4	3.3

Figure 4. Barrier Impact By Division For Each Instructional Solution
Participant assessment of barrier impact by Division by Instructional Solution. A score of 5 means all participants assessed the barrier to be always present. PD = Professional Development. Direct comparison between solutions is not possible because of differences in the structure of the questions.

References Coded as Barriers

The SOLUTION 1 collection yielded 477 coded Barrier category references, and SOLUTION 2, 752. Overall, the proportion for each main Barrier category remained roughly the same between the two solutions (Table 2). The greater number of references for SOLUTION 2 is most likely due to the inclusion of transcript comments.

Table 2. Coded References According To Each Barrier Category. The percentages are a function of the category count divided by the total number of references.

	Coded References per Category			
	Solution 1		Solution 2	
	Count	%	Count	%
Technology	116	24.3%	241	32.0%
Process	169	35.4%	245	32.6%
Administration	65	13.6%	114	15.2%
Environment	50	10.5%	54	7.2%
Training Stakeholder	77	16.1%	98	13.0%
Total	**477**		**752**	

References coded as themes

After categorizing participant references into Barrier categories for each solution, they were further organized into themes as described above. Thematic development involved clustering references addressing related topics, regardless of initial 'Barriers' categorization. Some references were included in multiple themes. For the SOLUTION 1 analysis this coding was performed in Microsoft Word, while for SOLUTION 2 it was performed in NVivo.

SOLUTION 1 Themes

During the SOLUTION 1 analysis, four major themes emerged: 1) Time Scarcity, 2) System Reliability, 3) Personnel, and 4) Communications. Time Scarcity was influenced by operational tempo, scheduling challenges, real-time constraints, and personnel time. Operational tempo refers to the busy nature of the CAF, making it difficult to develop and implement training programs. Scheduling issues arise from a lack of coordinated processes, and competing demands for maintenance and training time. Real-time constraints involve long system startup and load times, exacerbated when systems crash. Personnel often use personal time for learning and developing simulation training due to the absence of dedicated instructional roles. These issues could be addressed by, reducing system start times, optimizing system usage, and enhancing crash recovery processes. Providing remotely accessible courseware and documentation will help users learn offline and alleviate system burdens. System Reliability, although a prescribed Barrier category, also emerged as a pervasive theme, influenced by maintenance issues, supply chain constraints, and computer problems. Maintenance challenges include limited availability of personnel and restrictive contracts for reactive maintenance, and neglected preventative maintenance due to scheduling conflicts. Supply chain issues include restrictive contracts and unavailability of parts as technology ages, while computer problems such as freezing and crashing impact training effectiveness. Measures which could improve the reliability of SOLUTION 1 include establishing a preventative maintenance schedule (including software updates), conducting benchmark testing, and measures for maintaining a robust and flexible supply chain.

SOLUTION 2 Themes

The analysis of SOLUTION 2 identified six major themes: 1) After-Action Review and Learning Data Access and Content; 2) Restrictive Administration and Stewardship; 3) Contracting Constraints; 4) Infrequent Use vs. System Familiarity, Training Application, Acceptance and Buy-In; 5) Sufficiency; and 6), Succession and Posting. After-Action Reviews (AARs) are critical for feedback and performance evaluation but are often delayed and inaccessible, diminishing their value. Enhancing AAR accessibility and providing detailed, actionable feedback for all levels are necessary improvements. Restrictive Administration and Stewardship revealed issues with access, control, and maintenance of equipment, often reserved for high-readiness events and limiting lower-level training opportunities. Decentralizing equipment and utilizing regional centers of excellence for support and repairs could improve access and reduce skill fade. Clear information on equipment management and streamlined access requests would further enhance efficiency.

Contracting Constraints highlighted the dangers of over-reliance on contractors, which restricts technology use and reduces transparency regarding system access and responsibility. Training CAF personnel for first-line support and establishing dedicated support staff at centers of excellence could mitigate these issues. The theme of Infrequent Use vs. System Familiarity noted that infrequent use of SOLUTION 2 could limit effectiveness and familiarity, leading to poor training outcomes. Early and ongoing use, comprehensive training, and continuous promotion of the system’s benefits are necessary for better acceptance and buy-in. Sufficiency issues, such as a shortage of kit and support personnel, create inequities, particularly for reservists. Addressing these shortages and providing tailored training programs for reservists are crucial. Succession and Posting challenges involve knowledge loss due to personnel turnover. Standardized training, collaborative support functions, mentorship programs, and an online knowledge repository are recommended to improve knowledge transfer and continuity.

DISCUSSION AND CONCLUSION

Based on Pat Reid's 2014 categorization of barriers to implementing training technologies, we developed a questionnaire and focus group structure to systematically identify these barriers when attempting to adopt a specific training solution. This collection methodology has been used to assess potential barriers for two major training system improvement projects for the Canadian Army. The research method and analysis revealed significant barriers that both SOLUTION 1 and SOLUTION 2 face which may impede their optimal use, although the nature and specifics of these barriers differ. In both data collections, the proportion of identified Barriers within Reid's categories was similar between the two technologies, however somewhat different themes were revealed through the subsequent Grounded Theory analysis. Importantly, the inclusion of questionnaire and focus group input permitted examination of both individual and institutional impediments to training technology adoption.

The methodology has generated actionable insights which have been used to directly inform the design and acquisition of training technologies. Contextualized within use cases elicited during the focus group activities, the method provides targeted critiques and recommendations that can be incorporated into both procurement and service contracts to mitigate gaps present in the training organization, and to potentially improve solution development and deployment.

In this methodology, the Barriers categories behave as bins or identifiers. They provide users with a collection of functional elements found within the ecosystems of training organizations and offer focal points to consider organizational issues faced when implementing specific training technologies. However, the bins themselves (Barrier categories) are not necessarily the issue that must be addressed, and issues typically cross multiple bins. If one imagines an ecosystem with elements of soil and water, with toxic chemicals that are spilled into them, the problem is not "soil" or "water" but "toxic chemicals" *in* those things which impact each differently. In the same way, the common issue of Limited Time may impact the main Barrier categories of *Process, Administration,* or *Training Stakeholders,* but each differently. For this reason, the second part of the analysis – grouping like items into themes using a Grounded Theory approach – is of considerable importance, fostering a holistic view of the barriers as interconnected elements across the ecosystem.

Because commonly themed items span multiple categories, pervasive gaps within an institution could be identified using this method. It raises the possibility that the method might be used in the opposite direction, and instead of suggesting changes to instructional solutions, could be used to inform how the training ecosystem itself might be altered to better foster learning overall, regardless of training technologies used within the organization.

While the research has identified significant challenges in the implementation of training technologies, it also offers a clear framework for overcoming these barriers through strategic design and organizational alignment. The Grounded Theory approach to theme development enhances the relevance and applicability of the findings, providing a comprehensive understanding of the systemic issues at play. Future research should continue to refine this methodology and explore its broader applicability, ensuring that training technologies can be effectively integrated into complex organizational ecosystems.

Limitations

Important questions remain regarding the data collection methodology. Perhaps most critically, it is unclear whether it is possible to validate the Barriers categories themselves. Taken as a whole, they seem to be reasonable and logical, and apparently represent meaningful aspects of the instructional ecosystem of a learning organization. However, the authors have been able find neither supporting nor countervailing literature. Regardless, for the time being the categories offer a 'good enough' set of categories as a provocation to think about issues within an organization. A second significant problem is the reproducibility of the results. Collecting the references into the Barriers categories would likely be consistent across multiple analysts. However, the subsequent categorization of the references into themes might be considerably different by even the same analyst over time. To-date, one of the authors has performed all analyses.

Another important limitation concerns the participants in the study. Ideally, the participant sample will represent all members of the population using or facilitating use of the technology in all Barrier categories to fully capture all possible barriers and possible solutions. In the present work, there were very few participants from Process and Administration roles. Equally, contractors were excluded from the present collections because of conflicts of interest, however their input could add meaningful insight.

Additionally, the questionnaire is long, taking between 20-120 minutes to complete. The focus group format, while providing critical context and valuable data, is complex and resource intensive to facilitate. It is possible a more streamlined questionnaire would provide similar results, although such an approach might lack nuance and detail.

Finally, thematic categorization is labour intensive, and requires at least minimal domain knowledge of aspects of the technical solution, of pedagogy, and of the content area addressed by the solution. This is consistent with the Technology, Pedagogy and Content Knowledge (TPACK) model for instruction using technology, which stipulates a similar Venn diagram of intersecting skills (Koehler et al., 2013). Because such combined competencies are not always available in a single individual in the instructional or research space, collaborative approaches are needed. Indeed, for the present analyses the researchers often had to confer with military partners to understand context and nuance regarding features or instructional content. For larger or more complex datasets involving hundreds of participants or multifunction devices, the analysis would require more personnel with broad expertise, or collaborative teams of experts in the three TPACK domains.

Future Directions

We are currently in the process of standardizing and streamlining the data collection process so it might be applied by contractors as a sort of 'turn-key' solution. This would enable larger scale data collections, or multiple simultaneous data collections.

As mentioned above, data analysis in larger collections could be onerous, and would require collaborative teams for completion. An alternative may be to use artificial intelligence to perform preliminary analysis. During the most recent data collection, we used a large language model artificial intelligence (LLM AI) to provide a 'second reading' of the researcher's thematic categorization. The AI categorization was not entirely dissimilar to that of the human, but missed key details regarding human factors and use, and rendered considerably more categories compared to the human analysis. The AI also missed when a single reference might contribute evidence to more than one category. The current generation of LLM AIs are also subject to 'hallucinating'; inserting fabricated information, ideas or conclusions for no discernable reason. These spontaneous generations have the appearance of meaningful content but with no basis in reality. In this regard, future AI models may provide worthwhile explorations for large projects, but at present, may best be used to help human analysts look for gaps or oversight in their own work.

ACKNOWLEDGEMENTS

Thanks to Tim Lam, our SurveyMonkey wrangler, who along with Dr. Ramy Kirollos, Elaine Maceda, and Nada Pavlovic helped us to collect meaningful data. And thank you to the members of 2DIV, 3DIV, 4DIV and 5DIV, who generously gave of their time, expertise, and wisdom to provide these excellent insights.

REFERENCES

Alshammari, S. H., & Rosli, M. S. (2020). A review of technology acceptance models and theories. *Innovative Teaching and Learning Journal (ITLJ), 4*(2), 12-22.

Bennett W, Best C, Gillies I, Jarmasz J, Kerry J, Martin BCW, Pearce C, Rice B, Rowe L, Research Applications and Barriers to the Adoption of the Mission Essential Competencies (MEC) and Coalition Performance Evaluation Tracking System (C-PETS) under the JCTR Project Arrangement, TTCP Report 2020 DRDC-RDDC-2019-E20-0207-03355 2020

Freifeld, L. (2023). 2023 Training Industry Report. https://trainingmag.com/2023-training-industry-report/ Accessed June 04, 2024

GlimpseK12. (2019, 5/15/2019). Glimpse K12 Analysis of School Spending https://www.globenewswire.com/en/news-release/2019/05/15/1825260/0/en/Glimpse-K12-Analysis-of-School-Spending-Shows-that-Two-Thirds-of-Software-License-Purchases-Go-Unused.html

Jarmasz J, Martin BCW, Distributed Simulation for Training: Promises, Barriers and Pathways, NATO RTG Report, DRDC-RDDC-E18-0917-00777, 2018.

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is technological pedagogical content knowledge (TPACK)? *Journal of education*, *193*(3), 13-19.

Norman, G. (2010). Likert scales, levels of measurement and the "laws" of statistics. *Advances in health sciences education*, *15*, 625-632.

Reid, P. (2014). Categories for barriers to adoption of instructional technologies. *Education and Information Technologies, 19*(2), 383-407.

Rosenberg, J. M., & Koehler, M. J. (2015). Context and technological pedagogical content knowledge (TPACK): A systematic review. *Journal of research on technology in education, 47*(3), 186-210.

Singh, S., & Estefan, A. (2018). Selecting a Grounded Theory Approach for Nursing Research. *Global Qualitative Nursing Research, 5*, 2333393618799571. https://doi.org/10.1177/2333393618799571

Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories. Procedia manufacturing, 22, 960-967.